THE TELEGRAPHIC JOURNAL AND

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THE NATIONAL DEFENCES.

SOME few months since we availed ourselves of the opportunity afforded by some remarks from the Secretary of War, to direct special attention to the desirability of making, without further loss of time, that provision needed for the protection of our mercantile, as well as the more especially Government, naval ports. In the course of our remarks we dwelt upon the urgent need of a system of submarine mines being laid down at all such ports, of the provision of a ready means of communication between all coast stations and their respective centres, and of the advisability of educating local volunteer corps in the manipulation of such torpedo or submarine mining defences.

Mr. Stanhope has again addressed himself to the question, making known to his hearers a great deal of that which has been done, and also saying something with regard to that which yet remains to be done. Unfortunately—and we apply the term in the National interests—the defences of our coasts, as the protection of our ports, remain apparently still a dead letter—nothing has been done. What is to be done is, possibly, reserved for a future generation!

We recognise without stint the need for dispatch in the production of war munition of all kinds. That the necessary forts should be constructed: that they should be equipped with the requisite guns: that the deficiencies in this respect—the robbing of Peter to clothe Paul, the appropriation of guns required for our coast defences to Naval requirements—should, as speedily as possible, be made good: and we as readily admit the advantage attained under the administration of Mr. Stanhope by the widening of the area of production in the employment of private firms. We note with pleasure that not only is the production of large guns now committed to such firms as Whitworth and Armstrong, but also to others at Manchester and Sheffield. The fact that such guns require so long a period for their manufacture only intensifies the need for extending the source of manufacture and stamps as absurd the notion, which has so long prevailed, that their production should be confined to the Government factories. In this respect Mr. Stanhope wins the approval and support of his countrymen; and doubtless in some other respects there is room for congratulation. The amalgamation of the Ordnance Factories scattered throughout the kingdom; the new system of inspection of warlike material; the inquiries of the Select Committee on the Army estimates, will doubtless be productive of good; but all this still leaves very much to be desired. In point of fact, we are very little better off than we were at the time Mr. Stanhope favoured us with his former utterances. The country, as he very justly remarks, requires not only to know that it is getting value for its money, but that its power for defence is safe. Value for the nation's money is all very well, but where would the money be were England attacked and her means of defence inadequate to the occasion? All will rejoice that, amidst the armaments of other nations, we are to be in the future not one whit behind them; that in a short time our army is to be equipped with a new magazine rifle, which is, it is believed, superior to any now in course of manufacture by any foreign government. But here again we are still in the realms of the future. It is all what is to be, and none of that which in reality exists.

And so it is with our harbour defences. Mr. Stanhope says:—"I think I ought not to leave the question of harbour defences without a reference to a class of ports of which a good deal has recently been said. It has often been stated that the result of the recent Naval manœuvres has been to show the damage which in the event of war an enemy's cruiser could inflict upon our great centres of commerce situated near the coast; but no one, I suppose, thinks that these manœuvres, admirable as they are in their lessons and their experience, can, in all respects, be held to represent the real condition of affairs in time of war. All our important rivers would, in time of war, be protected by an elaborate system—a perfect network—of submarine mines, not to speak of other defences, for which the arrangements are now being perfected by the War Department." This is precisely what is required. It is practically what Mr. Stanhope said on a previous occasion. We do not doubt the matter is in hand, but it would be far more satisfactory to know and to feel that something really was being done. To merely plot out what is proposed upon paper is possibly a step towards its accomplishment, but it would prove a very poor one should occasion arise for putting it into immediate practice. We have on a previous occasion pointed out the inconvenience, if not impossibility, which would attend the laying down of a series of mines by the Royal Engineers, on an immediate call, sufficient for the protection of our chief ports or rivers. This is assuming that the Government is prepared with the necessary cables and other apparatus. We do not for one moment believe they are so prepared. We have heard of no such provision, and it is a matter so intimately affecting the electrical manufacturing interests, that we think, had such been in progress, we should have had some cognizance of it. Is it the intention of the Government to leave the whole matter on paper until the time arrives when, whatever may be the projected scheme, it must be at once laid down for the protection—such as it may be—of some one or other of our ports? To judge from Mr. Stanhope's remarks large sums of money are being laid out in ordnance and ammunition, and in the provision of forts. A considerable time must elapse before these can be said to be available for use. A few months would suffice for the production of the material necessary to lay down a complete network of submarine mines for the protection of our rivers and ports. Surely this would be better than nothing! At present what have we to fall back upon? Nothing! If we are to wait for forts we shall wait for years. A network of submarine mines means money, but as compared with the cost of ordnance and forts its cost is inconsiderable, whilst in point of time in production there is no comparison. The recent naval manœuvres have, in spite of what Mr. Stanhope says, shown us how perfectly many, if not all, our coast ports and harbours are at the mercy of an enemy. A fleet was appointed to defend them. It utterly failed, and port after port and town after town was run down and practically bombarded by a cruiser. Does Mr. Stanhope think that if ever war is declared against England we shall get six months notice? Would six months at the present moment place us in a fair position for defence?

The quickest and readiest as well as the least costly—if the question is one which admits of cost—is the provision of a complete equipment of mines for each of the ports or rivers to be so defended. These should be provided without loss of time, and storehouses found or built for their reception at or near the point they are required to defend until the time arrives—which we hope may be many a long day off—when they will be required. If this course is pursued, each port will have ready for use its own means of defence, and whether laid down when required by Royal Engineers despatched for the purpose, by local aid, or other means, it would require merely the despatch of men for the purpose. The subject is one of the utmost importance to the country at large, and we very fervently trust that it may no longer be deferred. It may be argued that such defences as we urge cannot be provided without also providing some means of protection for them. To this we reply that a means of protection may be, and probably is, desirable, but let us take the main chance first. Some place of security can surely be found somewhere near the point at which the apparatus will have to be used somewhat nearer than Chatham or Woolwich. We commend to Mr. Stanhope the consideration and development of some such a scheme as that which we have shadowed forth, and we feel that when he has succeeded in establishing it and thereby shown that we possess no longer the intention, but in absolute fact the means of defence, he will have earned, and will as surely receive, the hearty thanks of his countrymen.

THE *Western Electrician*, of Chicago, is seriously annoyed by the comparison between British and American electrical development, instituted in our leader six weeks ago. Most of our article is quoted without comment, but in the statement that "American smartness is not the kind of thing we should like to brag about," our contemporary sees an opportunity for indignant protest not to be let slip. "Such comments," it says, "are inspired by consuming jealousy and crab-bed narrowness" and it puts to its readers, or to us, we know not which, the somewhat enigmatical question "What is American smartness anyhow"? As a matter of fact we should really not like to say, and we are quite sure the *Western Electrician* would not like to hear. Sometimes it is revealed in the production of wooden nutmegs, sometimes in selling clocks which won't go. At one time it is manifested in the invention of Keely motors, at another time in producing tons of electrically refined sugar. There is really no limit to American smartness, and we feel that we are unable to deal with a question so vast. At the same time we must say that this display of outraged virtue from the city of pork corners, strikes us as very smart indeed.

THE contractor for the electric lighting of Barnet has found a staunch champion in a weekly electrical journal. The *Electrical Engineer* makes bold to say that the reports which have hitherto appeared on this subject are either based upon or copied direct from the gas journals, and that its contemporaries of the technical press find it easier to cut out or comment upon these articles than to visit the place itself. Somebody, who declares by inference that he is impartial and unprejudiced, has visited Barnet on behalf of our contemporary, and he finds the lighting is considerably better than was the case with gas; indeed from rough measurements made upon the spot, our informant calculates the light to be three times as powerful as the illuminant it was to displace. He draws the happy conclusion that if this pretty north London district wanted a good average light to replace at a similar expense that of the too confident and grasping gas company, this desire has been fully satisfied. As to the failure of the electric light, says the friend of Barnet, it went out twice at the beginning of the experiment.

IN another electrical contemporary of the same date, we notice that at a meeting of the Barnet Local Board on the 9th ult., a committee presented a report to the effect that as the electric lighting contractor had failed in his contract, and the light was indifferent, he be given fourteen days' notice to terminate the contract, but at the urgent request of certain members of the board it was decided to suspend the notice for a fortnight to see if the contractor made satisfactory progress. On the 23rd ult. the surveyor submitted a report as to the general condition of the lighting from the 3rd to the 22nd ult., and said he could not regard it as satisfactory. It was therefore proposed that the notice suggested by the committee should be served on the contractor, but an amendment was, however, brought forward to grant him another week's grace, and it was agreed that if, by that time satisfactory progress had not been made, notice should be given to terminate the contract.

IT is evident from the foregoing that Barnet has been going through a probationary period which seems likely to have a sorry ending. Even at the time we are writing the electric light may, under existing circumstances, have shed its last fitful rays, and it is difficult to see the *raison d'etre* for the attitude taken by our first mentioned contemporary. We, as mentioned in our issue of October 19th, paid a visit to Barnet one evening last month and after waiting till an hour after the gas in other portions of the district had been lighted up, and having been informed by shopkeepers that the glow lamps had failed three times on the preceding evening, we had to wend our way homewards in consequence of other matters more pressing, without being able to measure even roughly the intensity of the light as compared with the gas. In conclusion, we may quote the following lines from the London letter in the last number of the New York *Electrical World*, whose correspondent is, we believe, not unknown on the Editorial staff of one of the papers hereinbefore mentioned. "Any chance, however, of Barnet leading the way to a general introduction of electric lighting in this country has been summarily extinguished by the blundering of the contractor. Mr. Joel has added to his initial mistakes of trying to compete in price with gas and using small incandescents for street lighting by having at the very start a most regrettable breakdown. The position of central station lighting in England is hardly strong enough to warrant these 'accidents,' which, however, are sure to occur if a cheeseparing policy, induced by a desire to keep down the contract price, is allowed to prevail over engineering requirements."

WE have been asked to explain the proposed operations of Mr. Radcliffe Ward in electric traction. We really fear that this is at the present moment beyond our powers, but we may at least ask whether that gentleman and his friends seriously entertain the idea of running electrically-propelled omnibuses in the streets of London. Up to the present we can only point to one instance of commercially successful operations with tramcars propelled by electricity in England, so how can we expect omnibuses to run more advantageously? Perhaps Mr. Ward will be so good as to explain his method of procedure?

A CONTEMPORARY in describing a new form of lead-covered conductor points out one great advantage possessed by the types of cable in which each conductor is separately sheathed in lead is that a ready means is afforded for identifying any one wire at any point. Now we believe that the method of marking cables to which our contemporary alludes was patented by Latimer Clark about 1858 and used in some early cables. For instance, in the seven-wire Post Office cable, Holyhead to Howth, the six G.P. wires were marked with ribs 1 to 6, by a slight groove in the die of the G.P. machine.

THE Electrical Trades Section of the London Chamber of Commerce is now, we hope, placed upon a solid and substantial basis. The names of those who were elected to serve on the working committee were published in the REVIEW for October 26th, and on Monday the chairman and vice-chairmen were nominated. The discussion which took place at the general meeting of the trades, and the letter from Mr. Verity which we published last week, made it very evident that the section and the composition of the committee would be criticised from several points of view. *Electrical Plant*, the journal which started the idea of forming the section, thinks that the choice of members elected on the first permanent committee is not altogether a happy one, and that some of those chosen cannot feel themselves quite free from liability to be charged with inconsistency, inasmuch as they could see no good in the movement at first and pooh-poohed the whole scheme. When, however, they saw it being carried through, we learn that their enthusiam finally found vent in issuing postcards to canvass for votes on their own account. The choice of Mr. Crompton, too, as chairman, is, we think, calculated to raise thoughts in the minds of members of the trade just the reverse of the feelings to which our contemporary gave utterance in its early endeavours to push this matter to a favourable conclusion:—"That all personal and individual feelings must give way as far as possible to united advantages." It may be, however, that the saving clause in this quotation pretty fairly meets the case. Mr. Crompton has worked hard and well in the cause, and has been throughout Chairman of the Organising Committee, but it would have given more general satisfaction if a gentleman not so closely identified with a certain class of trade interests had been chosen to lead the entire body. So far as our part in the programme is concerned, we have gone to the limit which from the first we marked out for ourselves when honoured with a seat on the Organising Committee, and no further. We expressed our intention during one of the discussions of declining the nomination if elected on the Working Committee, and this we have done. It is easy to understand that much which will be discussed by the Committee will not be entered amongst the minutes of proceedings, and we must necessarily have been hampered in our journalistic capacity by matters which transpired of a private character. We have preferred, therefore, to await the disclosures of the business of the Section at its public meetings, so that we may be free to comment upon anything which seems to us desirable without any restrictions whatever, and we firmly believe that we shall be best serving the interests of the electrical trades by so doing, for it is only by such means that we can keep ourselves entirely free from anything which might possibly, to some extent, tie our hands in our desire to write fearlessly and independently upon any topic which may come under the notice of the Section, and, at the same time, avoid any suspicion that we are not absolutely impartial. We congratulate *Electrical Plant* upon the success of the movement, a success with which we feel as pleased as our contemporary expresses itself to be.

THE following has been sent to us:—"*Scene I.*—Charing Cross Station, District Railway. Passenger to Railway Official: Hollo a! what does this extravagance mean—electric light and gas burning at the same time? R. O.: Can't depend on the electric light, sir; comes too far! Passenger: Where does it come from? R. O.: Grosvenor Gallery. Passenger: Oh! (*Exit*). *Scene II.*—Street in City.—Merchant meets Whilom Passenger. Merchant: Well, what do you think about this Deptford Electric Lighting Station? Is it going to be a success? W. P.: I sincerely hope it is to be a grand success. Merchant: But what is your opinion as an expert in these matters? W. P.: There is no reason why it should not be the great success I hope, if the details receive the attention they deserve. Merchant: Well, I hope it may be; but how is it the Grosvenor Gallery supply cannot be depended upon? W. P.: Is that so? Merchant then recounts a little tale which convinces W. P. that a screw is loose somewhere. W. P.: I am very sorry to hear it. Perhaps they are giving so much attention to Deptford, that Grosvenor Gallery is neglected. Merchant: But is this wise? W. P.: Hardly; they should, I think, take particular care to give their present customers every satisfaction —*coûte qui coûte*—but they cannot well bestow too much attention on the Deptford installation. Merchant: I see you have the thing at heart. Ta, ta. W. P.: Most decidedly. Chin chin." We can only suppose that the City Merchant and W. P. are not aware that it has been the custom of the Grosvenor Gallery proprietors to cut off the supply from any one consumer without any warning for the sake of giving it to another; in other words, the demand has been greater than the supply.

THE SYNCHRONOUS MULTIPLEX TELEGRAPH SYSTEM.

(CONCLUDING REMARKS BY P. LA COUR.)

IT will be remembered that in 1882 Mr. Paul La Cour, the inventor of the phonic wheel, sold his patent, for the United States of America, to Mr. Jones, with the agreement of mutual communication of any possible improvements. In the same year Mr. La Cour communicated to Mr. Jones an *improved* method of synchronising the phonic wheel at two telegraph stations, and Mr. La Cour at the same time patented it in Europe. Mr. Jones formed a company, the Standard Electric Manufacturing Company, and their engineer, Mr. Patrick B. Delany, took out a number of patents, not only in America, but also in Europe, which treated of the same invention with such modifications as are easily effected with every invention. A committee of the Franklin Institute of Philadelphia rewarded Mr. Delany highly for "his" invention, and when Mr. La Cour protested that the invention was not Delany's, the same committee issued a report, the partiality of which was fully shown in the ELECTRICAL REVIEW of August the 26th, 1887.

Mr. Delany asserted in the *Electrician* of April the 27th, 1888, in reply to the different articles on this subject, that La Cour's original synchronism was an impossibility, and he adds (the *Electrician*, page 715): "If Mr. La Cour will pardon the suggestion, I would advise him to repeat his Fredericia and Nyborg demonstration, unless synchronism in that way has become a lost art. Its reproduction would throw much light on this question. If he succeed without the turntable, then I will publicly recant all my doubtings."

In the *Electrician* of May the 25th, Mr. La Cour took him at his word, and offered again to work his (La Cour's) *original* synchronism without the turntable, and as the dispute is really about the *improved* synchronism (which is so similar to that Mr. Delany patented afterwards, that he (Delany) has confounded the two in the synchronism given by La Cour to M. Cassagnes) La Cour offered also to work the improved synchronism entirely in accordance with his patent, in order to give Delany the opportunity of satisfying himself that both the original synchronism without the turntable, and the improved synchronism, could be maintained perfectly from morning until night. In that case Delany's right to the invention would be refuted, and La Cour therefore stipulated the condition that "Mr. Delany will pay me for the encroachment which he has made upon my rights the sum of £10,000 sterling, without it being necessary for me to go to law with him about his European patents."

As far as I can learn no reply has been given by Mr. Delany, and the natural conclusion to be drawn is, that he does not believe in his own assertion, that Mr. La Cour's synchronism is useless. The only thing that justified Mr. Delany in taking out so many patents, similar to Mr. La Cour's, was the fact that he considered La Cour's synchronism unworkable; therefore it seems proved that Mr. La Cour has been deprived of his rights, and that a compensation of £10,000 sterling would be moderate damages in a matter of so great importance. Mr. Delany's and the Standard Electric Manufacturing Company's silence can therefore, hereafter, only be interpreted in one way.

PRACTICAL NOTES CONCERNING THE CONSTRUCTION, USE AND MANAGEMENT OF STORAGE BATTERIES.

By A. RECKENZAUN.

(*Concluded from page* 201.)

WITH this issue we bring the series of "Notes" to a conclusion. The subject has by no means been exhausted—indeed, it has received but a general treatment; and the original object—viz., that of publishing a few important experiments and observations—had to be kept in view. Great strides have been made in the manufacture of storage batteries since the commencement of these "Notes," but the principles enunciated therein from time to time still hold good within the limits of their treatment. By far the greatest portion of these articles related to results of experiments made by the author, and these were limited to storage batteries of the most popular kind, composed of lead and oxides of lead. Up to a recent date these were the only commercially successful ones. Mr. Howell's new storage battery, which is now being introduced by Messrs. Crompton & Co., appears full of promise, but little is as yet known concerning its general properties. Mr. Howell's plates consist of spongy lead slabs produced by a peculiar process, the essential feature of which is kept secret. Contrary to popular notions, these plates are made to give considerable storage capacity, when compared with their weight, and the process of "forming" is said to occupy not more than two or three weeks, and without frequent reversals, differing therefore from the ordinary metallic lead or Planté types. Mr. Howell informed the author that a sample cell, containing 17 plates, weighing together 35 lbs., and each plate measuring 6 by 6 inches, gave a capacity of 185 ampère hours, at an average rate of 30 ampères, and that for the space of 10 minutes a discharge rate of 600 ampères had been maintained. According to this statement we have the very interesting fact that spongy lead plates can be made to yield 5·28 ampère hours per pound of metal at a considerable rate of discharge. Although no mention is made as to the durability and cost of these plates, we are assured that these items will be found satisfactory.

Copper as an Element in Secondary Batteries.—About seven years ago Mr. Sutton invented a storage battery composed of a lead plate to be peroxidised, and a copper plate to be alternately dissolved and deposited from the solution of sulphate of copper. This battery has not found any industrial application for obvious reasons: the action in a cell with metallic solutions is not constant, the layer of liquid in contact with the metal changes, and eventually refuses to act. In charging, soon after the first action there is no metallic salt present to decompose, but merely acid, which gives off gas, and then the metal deposit becomes non-adherent. In discharging, the metal salt forms too rapidly to dissolve and crystallises on the plate. These crystals form "trees," and eventually short-circuit the plates. It is for this reason, also, that the zinc-lead accumulator remains still within the precincts of the laboratory.

Messrs. Commelin, Desmazures and Bailhache in May, 1887, brought out a new accumulator, in which copper plays an important part. For the description of this we are indebted to M. Reynier's work, "L'accumulateur voltaïque."

The positive electrodes of this battery are made of porous plates, obtained from finely-divided copper under a pressure of 600 kilogrammes per square centimetre. Electrolytically-reduced copper, free from oxides, is used.

The negative electrodes are of tinned iron plates; these are amalgamated. The tin has to hold the mercury which does not adhere to the bare iron. The receptacle is made of tinned sheet steel; the negative electrode rests at the bottom of the box, and it is in contact with it. The electrolyte consists of water, zinc, and potash in the following proportions:—

Water	1,000
Zinc	144·67
Potash in solution	209·82
„ free	313·72

The positive electrodes are enveloped in parchment paper, and insulated from the negatives by means of glass rods. The parchment is stitched on, and although the seam is not watertight at first, it becomes so through the action of the liquid, which causes the paper to stick fast. The parchment undergoes a change through the action of the alkali; it swells and becomes brittle, but it appears to hold on a considerable time without breaking, if no mechanical disturbance takes place.

Without the parchment the action is irregular; the oxidation of the positive electrode is not complete, and deposits of zinc are mixed with copper; hence want of adherence and local actions or short-circuits through the formation of "trees," as in other batteries where metallic deposition takes place. These envelopes, therefore, play a very important part.

M. Finot, the chemist who examined this invention, gives the reactions during the discharge thus:

$$\text{Zn} + \text{KO, HO, Aq} + \text{Cu}_2\text{O} = \text{Zn O, KO, Aq} + 2\,\text{Cu} + \text{HO},$$

but there appears to be a doubt as to whether this is the correct rendering of the equation, and it requires confirmation; curiously, there are hardly two authorities who agree on the subject of chemical reactions in secondary batteries.

M. Finot ventures another theory in the *Bulletin de la Societé Internationale d'Electriciens*, where he states that during the charging of a copper accumulator one observes a curious phenomenon, which tends to show that oxygen does not combine with the copper, but that it may be occluded, and this occlusion may be due to peculiar properties of the porous plates.

When the apparatus is being charged one may observe that from the commencement of charging the level of the liquid rises and continues to rise until the charge is discontinued. On the other hand, during the discharge the reverse takes place; the liquid falls gradually, and does not resume its original level until the battery is entirely discharged. If, says M. Finot, the oxygen did combine with the copper, no rise in the level of the liquid would manifest itself until all the copper had entered into combination. Thus the oxygen fills the pores of the plates, displaces the liquid, and causes the increase in volume.

During the discharge again, oxygen should disappear immediately, and the liquid resume its normal level a few minutes after closing the circuit, but this is not actually the case.

M. Reynier thinks that these observations do not appear sufficient to demonstrate that occlusion of oxygen takes place in the positive plates, and he asks whether the rise of level in the liquid is not due to changes of volume in the plates, one of which is oxidised and the other covered with zinc? In order to decide this question the densities of the liquid as well as of the positive plates should be ascertained after the charge; from this may be deduced the total volume of the electrodes and of the liquid. By this method it could easily be determined whether the hypothesis regarding the occlusion of oxygen is correct.

The following weights and dimensions were given by M. Commelin, and they refer to an accumulator which has been constructed for the purpose of propelling a small torpedo boat. The storage capacity of the cell has been ascertained in the laboratory by the inventors:—

Weight of cell in working order ...	22·046 lbs.
„ „ 5 positive plates ...	4·25 „
„ „ 6 negative „ ...	2·32 „
Height „ positive plate	11·02 inches.
Width „ „ „	4·92 „
Height „ negative „	11·81 „
Width „ „ „	4·92 „
Surface of positive „	54·22 square inches.
„ „ negative „	58·1 „ „
Receptacle, length	5·905 inches.
„ width	3·346 „
„ height	15·75 „
„ weight	2·204 lbs.
Electrolyte (1·55 S.G.) weight ...	13·224 „
Useful E.M.F.	·75 volt.
Current, charging	15 ampères.
„ discharging	48 „
Time of charging	30 hours.
„ „ discharging	9¼ „
Useful capacity	413 ampère hours.
„ „	·42 H.P. hours.
Capacity per pound of cell	18·72 ampère hours.
„ „ „	14·12 watt hours.
Weight per H.P. hour	52·47 lbs.

According to a Note (communicated in March, 1888) by M. Krebs to the Académie des Sciences on "L'Essai d'un moteur électrique alimenté par des accumulateur destinés à un bateau sous-marin," the total weight of a Commelin-Desmazures battery to give 1 H.P. hour was found to be 37 kilogrammes, or 81·55 lbs.

This is not a very great advance upon what has been accomplished with certain lead storage batteries weight for weight. The volume, or dimensions of the copper storage battery are smaller than those made of lead, whilst the efficiency may be alike in both.

With regard to cost one may infer that lead and dilute sulphuric acid must be cheaper than copper and potash; and as to other points of interest we have to ask whether it is necessary to amalgamate the negative plates frequently? How long will the parchment envelope last? What changes take place with the electrolyte in the course of time? No doubt positive plates made of copper are more durable than those made of lead, but the general item, *depreciation*, has yet to be ascertained; if it turns out to be a very small quantity then we may ignore the question of first cost, and then we can congratulate Messrs. Commelin, Desmazures and Bailhache, as well as those in search of a novel storage battery, for an achievement, the beneficial results of which cannot easily be over estimated.

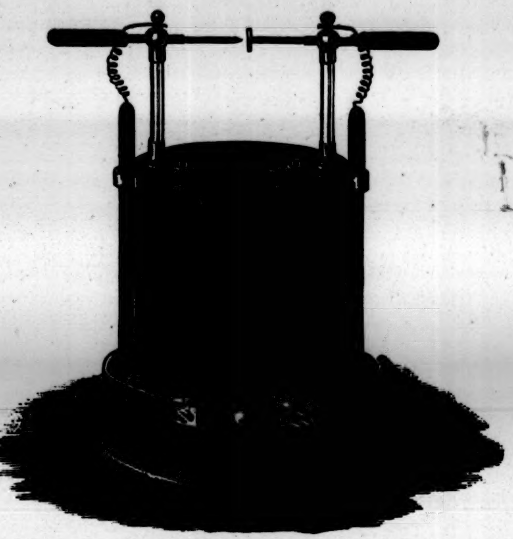
SPARK COILS.

IT is so long since we heard of any improvements in this class of apparatus, that we were inclined to think the subject a dead one, and that coils had attained to their utmost possible perfection. We have recently seen, however, some improvements which go far to disabuse our minds of the preconceived idea.

We illustrate below a coil made by Messrs. Woodhouse and Rawson under the patents of Messrs. Pyke and Barnett.

The cylinder on which rests the wooden top plate carrying the dischargers is the coil itself, which is hollow, and contains the break and commutator in its interior. The commutator is operated by the knob projecting from the wood at base of coil, immediately under which is the condenser, and below all a wooden base with feet. The coil is of an entirely different form and construction to anything we have previously seen. Inside of all is a hollow cylinder of iron wires, on this the primary, and on this again the secondary. The insulation is finally completed in a very neat and inexpensive manner by means of ozokerit, applied by a process which doubtless is one of the main points of Messrs. Pyke and Barnett's patents. The finished coil is in appearance an ebonite cylinder and is mounted without covering. The condenser is of similar manufacture and appearance, and the process of insulation is as great an improvement to the condenser as to the coil. The break is the only thoroughly practical one we have seen; while the old vibrating break would run but for a few minutes without attention, this is capable of really continuous work and is used for the coils applied to the manufacture of their lamps by Messrs. Woodhouse and Rawson, who inform us they find it invaluable for their work; as previously the break needed an attendant and even then the secondary current was subject to constant fluctuations. The coils more readily radiate heat than the old form; their insulation has also a higher melting point than paraffin, so that they will bear continuous working without harm.

The condenser is very small for its inductive capacity, as the dielectric between the foils, while not liable to rupture, is very thin and of a higher specific inductive capacity than paraffin. The break is a great advantage; as soon as the circuit is completed it starts working, and will continue to do so until the platinums require readjustment owing to their having worn away a very considerable thickness; for this purpose the top board of the coil on which the break is fixed is readily removable by loosening two nuts. The size of the coil shown is 5 inches × 5 inches and gives 2-inch sparks, and a perfectly continuous streak at 1½ inches, and of much greater vigour than the old form of coil, while, we are informed, it contains only



1½ lbs. of No. 29 wire, an extremely high commercial result; on adding a secondary condenser the spark may be increased five or six times in vigour without shortening.

Messrs. Pyke and Barnett inform us that they are indebted to Lord Crawford for some suggestions in respect to the design and manner of mounting, and it is thought that this invention will facilitate the work of the lamp manufacturer, the physicist, the physician and the amateur.

Messrs. Woodhouse and Rawson notify that they will be placing the condensers and breaks, each separately, on the market, the breaks arranged for use with the old form of coils.

ON THE SPEED OF DIFFUSION OF ELECTRO-DYNAMIC ACTIONS.

By H. HERTZ.

IF variable electric forces act in the interior of insulators whose dielectric constant differs appreciably from unity, the polarisations corresponding to those forces produce electro-dynamic effects. But it is another question if variable electric forces in the air are connected with polarisations of electro-dynamic efficacy. The inference has been drawn that if this question is to be answered in the affirmative, the electro-dynamic effects must diffuse with a finite rapidity.

Whilst vainly searching for experiments which could give a direct answer to the question raised, I was struck by the thought that it might be possible to test the above inference even if the speed in question should considerably exceed that of light. The plan adopted was the following: in the first place regular progressive undulations were to be produced in a wire extended in a rectilinear manner, by means of and corresponding to the rapid vibrations of a primary conductor. Secondly, a secondary conductor should be simultaneously subjected to the undulations propagated through the wire and to the direct action of the primary vibration as propagated through the air, both effects being thus brought into interference. Finally, such interferences should be produced at different distances from the primary circuit, and it should thus be determined whether or not the vibrations of the electric force at considerable distances showed a retardation of phase as compared with the vibrations near at hand. Any existing difference of phase would prove a finite speed of diffusion. This plan has shown itself practicable in all points. The experiments instituted accordingly have shown that the inductive action is propagated through the air with a finite speed. This speed is greater than that of the propagation of electric waves in wires. According to the experiments made so far, the proportion of the two velocities is as 45 : 28, whence the absolute magnitude of the former must be of the same rank as the speed of light. Concerning the diffusion of electro-static action no conclusion can as yet be reached.

The Primary and the Secondary Conductor.

The primary conductor (fig. 1) A, A′, consisted of two square plates of brass, the sides of which measured 40 centimetres, connected by a copper wire 60 centimetres in length.

In the middle of the wire was an interval for sparks in which the vibrations were introduced by the very powerful discharges of an inductorium, J. The conductor was fixed at the height of 1½ metre above the floor, in such a manner that the wire was horizontal, and the plane of the plates perpendicular. A right line, *r*, *s*, extended horizontally through the spark interval and perpendicular to the direction of the primary vibration will be considered as the fundamental line of our experiments. In this fundamental line we take as zero a point at the distance of 45 centimetres from the spark interval. The experiments were made in a large lecture room in which there were no solid objects within 12 metres of the fundamental line. During the experiments the room was darkened.

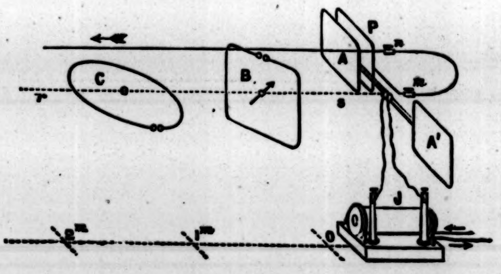


FIG. 1.

As the secondary track of the current there was employed partly the wire, C, having the form of a circle of 35 centimetres radius, and partly a wire, B, bent in the shape of a square, with sides measuring 60 centimetres. The spark interval of both conductors could be adjusted by a micrometer screw, and that of the latter was provided with a lens. Both conductors were in resonance with the primary conductor. The half duration of the vibration of all three, as calculated from the capacity, and the self-potential of the primary conductor was 1·4 hundred millionth of a second. It is, to be sure, uncertain whether the ordinary theory of electric vibrations yields here accurate results. That it has given correct numerical values for the discharges of Leyden jars leads us, however, to believe that the results here do not differ greatly in rank from the reality.

Let us now consider the action of the primary vibration upon the secondary circuit in some positions important for our purpose. We bring, firstly, the middle point of the secondary conductor into the fundamental line and let its plane coincide with a vertical plane passing through this fundamental line. We call this the *first main position*, and in it we perceive no sparks in the secondary circuit. This is easily explained, since the electric force is at all points perpendicular to the direction of the secondary wire.

We leave now the middle point of the secondary conductor in the fundamental line, but we bring its plane into a position perpendicular to the fundamental line, the second main position. Sparks are now seen in the secondary circuit as soon as the spark interval lies above or below the horizontal plane passing through the fundamental line. But there are no sparks if the spark interval coincides with that plane. The length of the sparks increases quickly at first, and then very slowly, with the distance from the primary vibration. I was able to observe the sparks in the entire distance at my disposal—12 metres—and I do not doubt that in larger rooms this distance could be extended. The sparks in this position are essentially due to the electric force which acts in the part of the secondary circuit situate opposite to the spark interval. The total force may be resolved into an electrostatic and an electrodynamic portion, the former predominating when near, and the latter at a distance, and determining the direction of the total force.

Lastly, we bring the plane of the secondary conductor into a horizontal position, still leaving its middle point in the fundamental line; this we call the *third main position*. If we use the circular conductor, bring its middle point to the zero of the fundamental line and move its spark interval slowly round, we observe everywhere a very active formation of sparks. The sparks are most powerful, and about 6 millimetres in length, when the spark interval is turned towards the primary conductor; they decrease regularly when the spark interval is removed from this position and reach a minimum value of about 3 millimetres at the opposite side. If the conductor were exposed to the electrostatic force only, we should expect a formation of sparks when the spark interval comes near the fundamental line on either side, and an extinction of sparks in both the intermediate positions. And the direction of the vibration would depend on the direction of the force in the part of the secondary conductor lying opposite to the spark interval. But over this vibration excited by the electrostatic force is superinduced the vibration produced by the force of induction, which is very powerful, because the inductive force here integrated around the secondary circuit, supposed to be closed, gives a finite integral value. This integral force of induction has a direction independent of the position of the spark interval and acts in opposition to the electrostatic force in the part of the secondary conductor turned towards A, A′, but in conjunction with it in the part turned away from A, A′. That in the latter position the inductive force predominates and determines the direction of the vibration, appears from the fact that the transition from one position to the other is effected without any extinction of the sparks. For our purpose the following remark is important: if the spark interval is turned 90° to the right or the left away from the fundamental line, it is situate in a nodal point in respect to the electrostatic force, and the sparks which occur owe their existence purely to the inductive force, and especially to the circumstance that the latter, taken around the closed circuit, differs from zero. In this particular position we can therefore examine the inductive action near the primary conductor quite independently of the electrostatic action.

Complete evidence for the explanations here given may be found in a previous memoir by the author, to be found in *Wiedemann's Annalen*, Vol. XXXIV., p. 155.

The Undulations in the Rectilinear Wire.

In order to produce in a wire, by means of our primary vibrations, progressive waves suitable for our purpose, we proceed as follows:—Behind the plate, A, we place a plate, P, of equal size. From the latter we convey a copper wire 1 millimetre in thickness to the point, *m*, of the fundamental line and from thence in an arch 1 metre in length to the point, *n*, which lies about 30 centimetres above the spark interval and then in a straight line parallel to the fundamental line onwards to such a distance that there is no fear of a disturbance by reflected waves. In my experiments the wire traversed the window, was carried about 60 metres in the open air and terminated in the earth. Special experiments showed that this distance was sufficient. If, now, we approximate to this wire a metallic conductor bent almost into a circle, a play of fine sparks in the latter accompanies the discharges of the inductorium. We can modify the intensity of the sparks by varying the distance of the plates, P and A. That the waves in the wire are of the same time of undulation as the primary vibrations appears, if we approach one of our secondary conductors to the wire. In these the sparks are more powerful than in any other metallic circuits, greater or smaller. That the waves are regular in space as well as in time can be proved by the formation of standing waves. For this purpose the wire is allowed to end freely at some distance from its origin and we approach to it one of the secondary conductors in such a position that the plane of the latter receives the wire to which the spark interval is turned. We observe the following phenomena: at the free end of the wire the sparks in the secondary conductor are very small; they increase in length as we approach the origin of the wire but they decrease again and sink almost to zero, increasing again subsequently. We have found a nodal point. If we now measure the wave length thus found and make the entire length of the wire, reckoning from *m*, equal to a multiple of this length by a whole number and repeat the experiment, we find that now the entire length is divided by nodal points into distinct waves. If we determine carefully each nodal point and mark it by means of a paper "rider," we can convince ourselves that the intervals of the latter are approximately equal and that the experiments admit of some degree of accuracy.

The nodal points may be also distinguished from the intervals in other manners. If we approach the secondary conductor to the wire in such a manner that the plane of the former is placed vertically upon the latter, but that the spark interval is turned neither quite to the wire nor quite away, but is in an intermediate position, the secondary circuit is capable of indicating forces which are perpendicular to the direction of the wire. In such a position of the circle we see sparks appear at the nodal points, but disappear in the intervals. If we draw sparks from the wire by means of an insulated conductor these are somewhat stronger at the nodal points than in the intervals, but the difference is small, and can generally be recognised only if we know where the nodal points are situate. That the last named method, and others of a similar nature, give no distinct results is due to the circumstance that other irregular movements are superimposed upon the waves in question. But by means of our definite circles we can trace out the movements which interest us, just as it is possible to hear definite tones in the midst of noises by the aid of resonators.

If we cut off the wire at a nodal point the phenomena in the part towards the origin remain unaltered, and even in the severed portion, if left in its place the waves are still propagated, though with diminished strength.

The measureableness of the wave lengths admits of various applications if we substitute for the copper wire previously used a thicker or a thinner copper wire, or a wire of a different metal, the nodal points retain their position. The speed of propagation in all such wires is hence equal, and we are entitled to speak of it as a fixed velocity. Iron wires form no exception to the general rule, the magnetic property of iron not coming into account in such rapid movements. It will be interesting to test the behaviour of electrolytes. The circumstance that in such the electric movements are combined with the motion of inert masses would lead us to expect a lower speed of propagation. Through a tube of 10 millimetres in diameter filled with a solution of sulphate of copper the waves were not propagated at all, the excessive resistance being possibly the reason. By measuring the wave lengths the relative periods of vibration of different primary conductors may be determined. In this manner the vibratory periods of plates, spheres, ellipsoids, &c., may be compared.

In our particular case it appeared that the nodal points were very distinct if the wire was cut off at

8 metres or at 5½ metres from the zero of the fundamental line. In the former case the paper riders used for the determination of the nodal points were at 0·2 metre, 2·3 metres, 5·1 metres and 8 metres; in the latter at 0·1 metre, 2·8 metres, and 5·5 metres distance from the zero point. It is clear that the (half) wave length in the free wire can differ little from 2·8 metres. That the first wave length reckoned from P appears smaller is not surprising if we consider the presence of the plate and the curvature of the wire. From a duration of vibration of 1·4-hundred millionth of a second, and a wave length of 2·8 metres, there results that the speed of propagation of electric waves in wires is 200,000 kilometres per second. Fizeau and Gounelle determined this speed by a very good method as 100,000 kilometres in iron wires, and in copper wires as 180,000 kilometres. W. Siemens, in 1875, found speeds of 200,0000—260,000 kilometres per second in iron wires, making use of Leyden jars. Other measurements can scarcely come into consideration. Those experimental values fall on either hand of our result. But as our value is found by the aid of a doubtful theory we cannot proclaim it as a new measurement of the same magnitude, but, on the other hand, we may assume from the agreement with experimental results that our calculation of the period of vibration is approximately correct.

Interference of the Direct Action, and of that conveyed along the Wire.

We place the square circuit, B, on the zero point in the second main position so that the spark interval is uppermost. The waves in the wire have now no influence, and the direct action occasions sparks of 2 millimetres in length. If we bring B by rotation on a perpendicular axis into the first main position, a direct action of the primary vibration does not take place, but the waves in the wire produce sparks which may be also brought to near 2 millimetres in length by approaching P to A. In the intermediate positions both causes will occasion sparks, and the possibility occurs that they may mutually reinforce or weaken each other according to their difference of phase. We observe, in fact, a phenomenon of this nature. If we place the plane of B so that its normal turns away from that side of the primary conductor on which is the plate, P, the sparks are more powerful than even in the main positions; if we place that plane so that its normal points towards, P, the sparks expire and reappear only if the spark interval is greatly reduced. If under circumstances otherwise the same, we place the spark interval at the lowest point of B, extinction occurs when the normal points away from P.

Further modifications of the experiment in which, *e.g.*, the wire was passed beneath the secondary conductor gave results which might have been expected from what has gone before. The phenomenon itself we had expected, but we must explain that the direction of the action was in accordance with our interpretation. Suppose the spark interval situate at the summit and the normal turned towards P as in the figure. Let us regard a point of time in which the plate, P, is the state of a maximum positive charge. The electro-static, and therewith the entire force, is directed from A towards A′. The vibration thus produced in B is determined by the direction of the force in the lower part of B. The positive electricity is thus driven towards A′ in the lower part, and away from A′ in the upper part. Let us now consider the action of the waves. As long as A has a positive charge, the positive electricity flows out of the plate, P. This current, in the moment which we consider in the middle of the first half wave length of the wire is at the maximum of its development. At the distance of a quarter of a wave length further from the commencement, *i.e.*, near our zero point, it is about to assume the direction leading away from the zero point. Here, therefore, the inductive force drives the adjacent positive electricity towards its origin. Especially in our conductor, B, the positive electricity is thrown into such a rotatory movement that in the upper part it tends to flow towards A′, and in the lower part away from A′. Hence, in fact, electro-static and electro-dynamic forces work against each other in almost equal phases, and must annul each other more or less completely. If we turn the secondary circuit ronnd by 90° through the first main position, the direct action changes its sign, but not the action of the waves, and the two causes reinforce each other. The same holds good if we turn the conductor in its plane so that the spark interval is at the lowest point.

We now introduce instead of the wire, *m*, *n*, greater lengths of wire. We perceive that the interference becomes constantly less distinct, and if we introduce a wire of 250 centimetres in length it disappears entirely, and the sparks are equally long whether the normal points to P or away from it. If we prolong the wire further there appears again a difference of the several quadrants, and the extinction of the sparks in one quadrant becomes very distinct when 400 centimetres of wire are introduced. But now, in contradistinction to what previously occurred, extinction occurs when the spark interval is uppermost, and the normal points away from P. On further elongation the interference vanishes anew and returns in its former direction, if about 6 metres of wire are introduced. The explanation of these phenomena is due to the retardation of the waves of the wire.

If we wish to produce interferences whilst the secondary circuit, C, is in the third main position, we must remove the straight wire from its previous position and carry it past the horizontal plane on C, either on the side of the plate, A, or the plate A′. In practice it is sufficient if we extend the wire loosely, seize it with an insulating forceps, and approximate it alternately to one or the other side of C. We observe the following phenomena: if we conduct the waves along that side in which is the plate, P, the waves annul the sparks which previously existed. If we convey the waves along the opposite side they reinforce the sparks previously existing without regard in either case to the position of the spark interval. We saw that at the moment in which the plate, A, is in the state of the strongest positive charge, and in which, consequently, the primary current begins to flow away from A, the current at the first nodal point of the rectilinear wire begins to flow away from its origin. Both currents, therefore, circulate round C in the same direction if the straight wire lies on the side of C turned away from A, but in the opposite case they travel round C in antagonistic directions, and their effects annul each other. That the position of the spark interval is indifferent is proved by our assumption that the direction of the vibration is here determined by the electro-dynamic force. The interferences last described have their direction inverted if we insert between the points, *m* and *n*, 400 centimetres of wire in place of 100.

In such positions, also, in which the middle point of the secondary circuit is outside the fundamental line I have produced interferences, but for our present purpose they are important only in so far as they confirm our fundamental views.

(*To be continued.*)

REVIEW.

Central Station Electric Lighting. By KILLINGWORTH HEDGES, M.I.C.E. E. and F. N. Spon, London.

THERE is nothing in this book requiring special notice, the matter being apparently a carelessly arranged and hastily compiled *rechauffé* of papers written during the last two years and read at the meetings of various scientific societies. The work is intended to popularise the idea of distributing electricity from central stations, and may be found useful for this purpose, though the method of treatment is far from scientific.

A PRACTICAL CONCEPTION OF THE ELECTRIC FIELD.

By JOHN GRAY, B.Sc.

(*Concluded from page* 483.)

PART III.

WITH the help of a diagram similar to that in fig. 9, it is easy to show the effect of giving a positive or negative charge to a conductor, or, what is equivalent, raising or lowering its potential.

Fig. 10 is a potential diagram of an electric field with parallel tubes of force, in which a conductor, A B, is placed, as already described in fig. 9.

Let us assume that the potential of A B is increased by an amount B F, by imparting a positive charge to it (B F has been taken so as to bring C to the potential of the surrounding field, merely to simplify the diagram), the potential diagram for the tube of force containing the conductor will now be Y C F X. It can be easily seen that the inclination, F X, is greater than the inclination of Y C, *i.e.*, the E.M.F. at F is greater than that at C. The conductor, therefore, when positively charged will be repelled from the positive pole of the field. This explains the well-known law that *similarly electrified bodies repel one another*. On the other hand, let us suppose that the potential of the conductor is reduced by an amount represented by the line, B D, by imparting a negative charge to it. Y E D X will then represent the potential diagram for the tube of force containing the conductor. In this case we see that the inclination of Y E is greater than that of D X, *i.e.*, the E.M.F. at E is greater than the E.M.F. at D, and consequently the negatively-electrified conductor will be attracted towards the positive pole of the field. This explains another well-known law, that *bodies when oppositely electrified attract one another*.

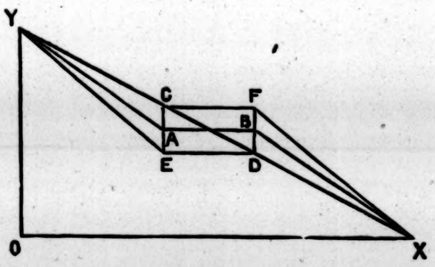


FIG. 10.

Hitherto we have considered the case of parallel tubes of force; we will now consider the case of conical tubes of force, such as would be produced by an electrified point placed at the centre of a spherical conductor, or at an infinite distance from all conductors.

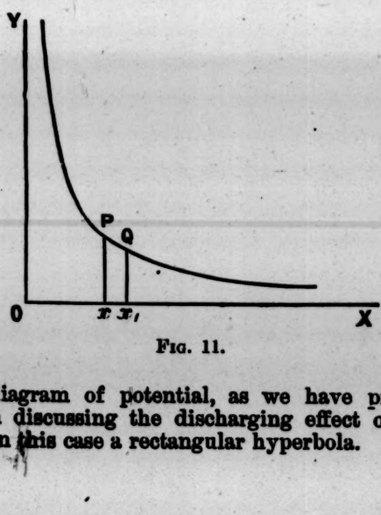


FIG. 11.

The diagram of potential, as we have previously stated in discussing the discharging effect of points, will be in this case a rectangular hyperbola.

Let O (fig. 11) denote the position of the point; O X the axis of the conical tube of force. A line, P x, drawn from any point, P, in the hyperbolic curve represents the potential at a distance, O x, along the axis of the conical tube of force.

The following considerations will show that the diagram of electric potential for an electrified point is a hyperbola. The steepness of the curve, or the inclination of a line tangent to it at any point, is represented by the difference of height between two successive ordinates, say P x and Q x, divided by $x\,x_1$ the distance between them. This inclination of the tangent in the diagram represents, therefore, the rate at which the potential decreases, that is the E.M.F., which, as we have seen, is the stretch on the elastic diaphragm of the electric cell. The stretch on any diaphragm in a conical tube of force has been shown to be inversely proportional to the square of its distance from the electrified point; therefore, in the diagram of potential for this case, the inclination of the tangent of the curve must be inversely proportional to the square of its distance from the origin, O. This is known to be a property of the hyperbola.

If a small neutral conductor is placed in a field due to an electrified point, it will be seen from the above explanation that the E.M.F. at the end nearer to the electrified point will always be greater than that at the other end. Or if we return to the conception of the elastic conical tube of force, it will be evident that the end of the conductor nearest to the apex of the cone will be in contact with a diaphragm having a greater stretch or distortion than that in contact with the end of the conductor furthest from the apex of the cone or electrified point. Hence neutral bodies will be always attracted to an electrified point, and obviously the attractive force will be greater the nearer the neutral body is to the electrified point.

Capacity.

A Leyden jar, as is well known, consists of a glass bottle or jar, coated inside and outside with conducting substances such as sheets of tinfoil. It is charged or filled with electricity by connecting the outer coating to the earth, and the inner coating to the electric machine or other source of electricity. It is found that a much greater charger of electricity can be imparted to the inner coating of the jar, than if the same surface of tinfoil were placed on an insulating stand at a distance from all other conductors. To understand the explanation of this, we must fix our minds on the dielectric, *i.e.*, the glass forming the substance of the sides of the Leyden jar. When a charge is given to the inner coating of the jar, parallel tubes of force pass across the glass to the outer coating which, being in connection with the earth, is at zero potential. The whole difference of potential has thus to be sustained by the diaphragms of the tubes passing between the inner and outer coatings. These tubes are very short compared with those from a conductor placed, say, in the centre of a room. Hence there are a much smaller number of elastic diaphragms to resist the whole difference of potential or pressure due to the electric machine, and each of the diaphragms will be stretched to a much greater extent. Now the extent to which the first sheet of diaphragms is stretched is a measure of the total amount of free electricity or electrification on the conducting surface. The diagrammatic sketches (fig. 12) will show more clearly how the charge on a Leyden jar depends on the thickness of the glass. The thickness of the glass in B is double that in A. The tube of force in B will therefore, as illustrated, have double the number of elastic diaphragms that A has. The same difference of potential between the two coatings will have to be supported by two diaphragms in the case of A, and four diaphragms in the case of B. Each diaphragm will thus be stretched to double the amount in A that it is in B. Thus the amount of the electric fluid absorbed by the inner coating will be double in A what it is in B. The following law can easily be deduced from the above explanation :—*the charge of a Leyden jar is proportional directly to the* *potential of the charge, and the superficial area of the coating, and inversely proportional to the thickness of the glass.*

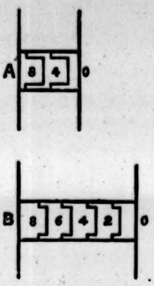


FIG. 12.

The *capacity* of a conductor is proportional to the displacement of the elastic diaphragms close to the surface of a conductor, produced by one unit difference of potential between the two poles of the dielectric. It is proportional to the whole charge on the conductor divided by the potential, or, in the Leyden jar, to the surface divided by the thickness of the glass. The *capacity* of a Leyden jar is very large, for the reasons given above.

We will now investigate the electrical capacity in another simple case, viz. :—The capacity of a spherical conductor at an infinite distance from all conducting bodies. If a certain quantity of electricity is placed at the point, P, at an infinite distance from all conducting bodies, the tubes of force produced in the surrounding dielectric will, as we know, be conical in shape. C P D represents the section of a portion of one of these tubes. Let A and B represent sections of two conducting spheres of which the radii are respectively R_1 and R_2, and having P as a common centre. A quantity of electricity equal to that at P placed on the section E G of A, or F H of B, will produce the same external tube of force as P, since E G and F H may be taken to represent elastic diaphragms in the tube at which the same quantity of electricity is displaced as at P.

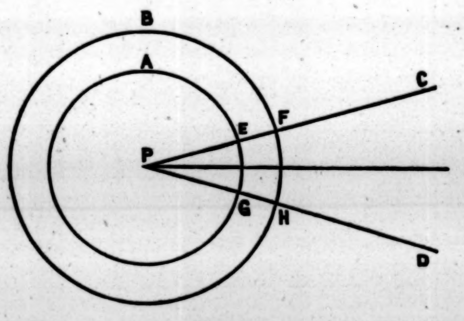


FIG. 13.

We will now suppose that the electricity is removed from P, and that the sections, E G and F H, are charged successively to the same pressure or potential, then the ratio of the displacement of the diaphragm at E G to that of the diaphragm at F H will be the ratio of the capacity of A to that of B. The displacement of a diaphragm is inversely proportional to the elastic force pressing it back to its normal position ; that is to say, the greater the elastic force resisting the displacement, the less will be the displacement. The elastic resistance of the diaphragm, E G, is equal to the sum of the elastic resistances of all the diaphragms external to it, extending to an infinite distance, *i.e.*, the sum of an infinite series $\frac{1}{R_1^2} + \frac{1}{r^2}$ (to infinity). The sum of this series can be shown to be equal to $\frac{1}{R_1}$. In the same way we can prove that the elastic resistance at F H will be $\frac{1}{R_2}$. The displacements at E G and F H with a given potential will therefore be inversely as $\frac{1}{R_1}$ to $\frac{1}{R_2}$, *i.e.*, directly in the ratio of R_1 to R_2. Hence it follows that the capacities of two spherical conductors, A and B, are proportional to their radii ; or, if we choose the proper unit of capacity, *the capacity of a sphere at an infinite distance from all other bodies, is equal to its radius.*

We have discussed above how the capacity of a conductor is modified by the dimensions of the electric field. It has been found by experiment that the capacity of a conductor depends on the nature of the substance of the dielectric. For instance, if glass be substituted for air between two conducting surfaces, the same difference of potential between the two surfaces will impart more than three times the quantity of electricity to the charged conductor. This means in our theory that the elastic diaphragms in glass have only one-third the elastic resistance of those in air, and that the same pressure will produce three times the amount of displacement or stretch of the diaphragms. The displacement of the elastic diaphragms of any substance compared with those of air correspond to what is called the *specific inductive capacity* of the dielectric.

Quantity and Density.

It remains now only to give the explanation of the terms quantity and density, in terms of our conception, to complete the list of important magnitudes we meet with in the study of statical electricity, and we do not intend at present to apply it to electro-magnetic phenomena. We have assumed in this theory that electricity is an incompressible fluid with which the pores of all bodies are always filled. When an insulated conductor has received a positive charge of electricity, however, the amount of the charge will not be the total quantity of electricity in it, but the excess which is added to it. This excess will be represented by the total volume swept through by the elastic sides of the skin of diaphragms which is supposed to form its bounding surface. When a negative charge is imparted to a body a certain quantity of the normal charge is abstracted and the elastic skin of the conductor is pressed inwards from its normal position, the quantity of the charge being represented by the volume swept through by the skin when it is pressed inwards.

The *density* of an electric charge is the quantity of free electricity or electrification on a unit area of the surface of the conductor. This density will evidently be proportional to the displacement of the elastic skin over the given area.

The Electrophorous.

We will conclude by giving an explanation of the action of the electrophorous in terms of the electric cell theory. The electrophorous, as is well known to every student of electricity, is one of the simplest machines for obtaining a continuous supply of electricity by means of electrical influence and mechanical work. It consists of a resinous cake contained in a metallic dish, and a metallic disc slightly smaller in diameter than the resinous cake, having an insulating handle by which it can be placed upon the cake. The resinous cake is rubbed with a cat's skin to impart a negative electrification to its upper surface. This means that the pressure in the electric cells of the dielectric above the cake will be below average pressure or zero, that in fact there will be a partial vacuum in the cells. If we now place the metallic disc (which will be represented by an elastic bag) on the surface of the cake by means of its insulated handle, and the fluid in the elastic bag be put in communication with the earth, which is taken as zero of pressure, the pressure inside will be greater than the pressure outside, and the elastic bag will be expanded. Now shut off communication with the earth, remove the bag (*i.e.*, the disc) to a neutral part of the field, and bring the knuckle, or some other pointed conductor which is in connection with the earth, near the disc. The expanded elastic bag is now free to exert its full elastic pressure on the fluid inside it, and a discharge or spark will take place to the pointed conductor in its neighbourhood. The diagrammatic sketch (fig. 14) of the electrophorous will help to make this clear. The metallic disk, A, supported on an insulating handle, B, is supposed to consist of an elastic bag. The resinous cake, C, is a dielectric, and when excited by friction its elastic diaphragms, as represented by the dotted lines, are strained inwards. This produces an electric vacuum or negative potential in the dielectric air above the cake. The elastic bag, A, when placed on the cake is surrounded by this vacuum, and when a communication is established between the inside of the bag and the earth by means of the tube (*i.e.*, the conductor), E, which is connected to the metallic plate or dish, D, resting on the earth, then the electric fluid will flow from the earth into the bag and expand it till equilibrium is reached. If the connection, E, is now broken, and A is removed till it is surrounded by a neutral field, the full pressure of the elastic bag will be exerted on the fluid inside the bag and drive it through any channel which may lead it to the earth.

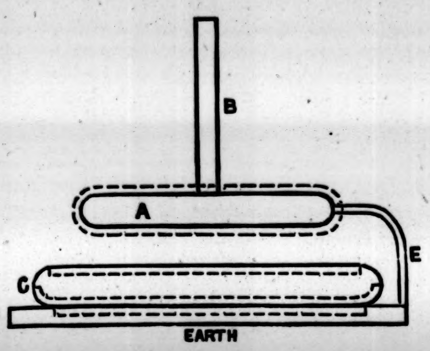
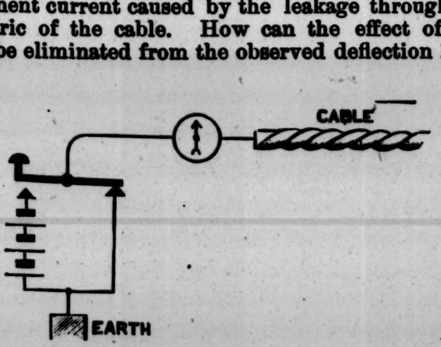


FIG. 14.

Finally, we will repeat the caution with which we started, that the aim of this paper is not to give a true picture of the constitution of matter, but to supply to the practical man concrete representations of the various electrical magnitudes and their relations.

GALVANOMETER DISCHARGE DEFLECTIONS.

IN taking capacity tests of a long cable, if the charging current is allowed to pass through the galvanometer, which would be the case if the connections were arranged as shown by the figure, then the deflection observed is due partly to the charge and partly to a permanent current caused by the leakage through the dielectric of the cable. How can the effect of this latter be eliminated from the observed deflection?



If the key be kept depressed after the charge deflection has been noted, and until the galvanometer needle comes to rest, the latter will be permanently deflected under the influence of the leakage current, and if this deflection be noted, we can, from it and the observed charge deflection, determine what the deflection due to the charge alone should be.

Let D be the observed charge deflection,
„ δ „ „ „ permanent deflection when the needle comes to rest.
„ C be the constant current producing the permanent deflection, δ, and
„ $m\,k^2$ be the moment of inertia of the needle.

The charge quantity, Q, has the effect of making the needle start off with an initial angular velocity,

$$\omega = \frac{Q}{m\,k^2},$$

it then ceases to act.

Calling μ the constant of the galvanometer needle, which depends upon its shape, magnetic strength, &c., we have the equation of motion

$$m\,k^2 \frac{d^2\,\theta}{d\,t^2} = C - \mu\,\theta = \mu\,(\delta - \theta)$$

because there is no acceleration when $\theta = \delta$.

Therefore

$$2\,\frac{d\,\theta}{d\,t} \cdot \frac{d^2\,\theta}{d\,t^2} \cdot m\,k^2 = 2\,\mu\,(\delta - \theta)\,\frac{d\,\theta}{d\,t}$$

or

$$m\,k^2 \left(\frac{d\,\theta}{d\,t}\right)^2 = A - 2\,\mu\,\delta\,\theta + \mu\,\theta^2.$$

Now when

$$\theta = 0 \qquad \text{then } \frac{d\,\theta}{d\,t} = \omega$$

and when

$$\theta = D \qquad \text{then } \frac{d\,\theta}{d\,t} = 0.$$

Therefore

$$A = m\,k^2\,\omega^2$$

and

$$0 = A - 2\,\mu\,\delta\,D + \mu\,D^2$$

that is

$$0 = m\,k^2\,\omega^2 - 2\,\mu\,\delta\,D + \mu\,D^2.$$

Now, if C did not act, δ would equal 0, and when this is so the total deflection equals d, say, therefore

$$0 = m\,k^2\,\omega^2 + \mu\,d^2$$

therefore

$$0 = -\,\mu\,d^2 - 2\,\mu\,\delta\,D + \mu\,D^2$$

that is

$$d^2 = D^2 - 2\,\delta\,D$$

or

$$d = \sqrt{D\,(D - 2\,\delta)}.$$

Thus if the observed discharge deflection, D, were 200 divisions, and the permanent deflection, δ, after the needle had come to rest were 19 divisions, then the discharge deflection, d, which would have been obtained had the leakage in the cable not existed would have been

$$d = \sqrt{200\,(200 - 2 \times 19)} = 180.$$

It may be remarked that the above formula was given by Mr. C. Hockin in the No. of the REVIEW for August 15th, 1876, page 222, though no proof of the same was shown.

H. R. KEMPE.

The Blackpool Tramway.—Mr. Holroyd Smith writing under date of November 7th says:—I have to-day seen Mr. Slater Lewis's letter, and would reply at some length if any good purpose would be served thereby, but as the position Mr. Lewis has taken leaves me no alternative but to place the matter in my solicitor's hands, I shall do so and act as advised.

APPROXIMATE MAGNETIC SATURATION.

A CORRESPONDENT has asked for a simple formula for determining the number of ampère-turns required to produce approximate saturation in masses of iron of given dimensions. He gives us a diagram, and says :—"Supposing the above represents the saturation curve, the point at bend A is what I want, *i.e.*, the *useful* saturation." The following may help our correspondent. The information may be found with a little digging out in Kapp's paper on the "Predetermination of Characteristics of Dynamos" and in Hopkinson's paper on the same subject.

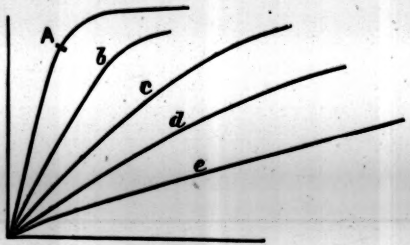


DIAGRAM.

In the first place, the bend, A, means nothing. If the magnetic circuit is nearly all iron the bend is well defined, as on sketch; if part air (*b*) less defined; if more air (*c*) still less defined, until when nearly all air and little iron (*e*) the line of magnetisation is straight. Before the ampère-turns can be calculated, it is necessary to be able to calculate the resistance of the magnetic circuit, and this can only be done if the length of the air gap is small compared with its cross section, for it is only then that the dimensions of the path through the air to which the lines confine themselves can be calculated. For example, one could calculate with fair accuracy the cross section of the path at A, fig. 1, but one could not even approximately calculate the cross section in fig. 2, as the lines stray all through space. It all depends, then, upon whether one can calculate the dimensions of the air space; and if this can be done, the formula, assuming that 15,000 C.G.S. units will satisfy our correspondent, this being approximate saturation, is as follows :—

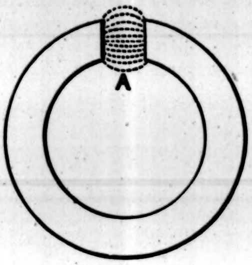


FIG. 1.

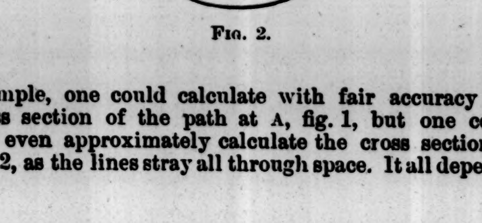


FIG. 2.

Let A be the ampère-turns.
Let I be intensity of field through the air space.
Let 15,000 be intensity through the iron.
Let L length of iron in c/m.
Let *l* length of air in c/m.

Then approximately $A = 30\,L + \frac{l\,I}{1 \cdot 2566}$.

THE ELECTRICAL AND ALLIED TRADES' SECTION OF THE LONDON CHAMBER OF COMMERCE.

AT a meeting of the committee held on Monday afternoon last, it was first resolved that the presence of the reporters at that particular meeting be sanctioned. Sir Daniel Cooper moved a resolution to the effect that in the case of firms and companies elected to the committee they should be required to nominate the individual by whom they would be represented. The resolution was not carried; but it was arranged that the secretary should request the companies concerned to state by whom they would be represented on the committee. The report of the scrutineers of the election was then received, and letters declining the nomination were read from Sir James Anderson, Messrs. Alabaster & Gatehouse, and Mr. Quintin Hogg. The committee proceeded to fill the vacancies so created and to decide the ties which had occurred in the balloting in the Telegraph Companies' and Electrical Manufacturers' Sub-Sections, the result being that the committee has been finally constituted as follows :—

Telegraph Companies (5).

Sir John Pender (Eastern Telegraph Company).
Mr. J. H. Tritton (Indo-European Telegraph Company).
The Marquis of Tweeddale (Eastern Telegraph Company).
Mr. C. W. Earle (West India and Panama Telegraph Company).
Mr. R. K. Gray (Spanish National Submarine Telegraph Company).

Telephone Companies (3).

Mr. J. Brand (United Telephone Company).
Colonel R. R. Jackson (National Telephone Company).
Mr. H. Grewing (Oriental Telephone Company).

Electrical Manufacturers and Contractors (13).

Mr. R. E. Crompton (Crompton & Co.).
„ Alex. Siemens (Siemens Bros. & Co.).
„ M. Immisch (Immisch & Co.).
„ E. Garcke (Anglo-American Brush Electric Light Corporation).
„ F. L. Rawson (Woodhouse & Rawson).
„ B. Pell (Johnson & Phillips).
„ C. J. Wharton (Laing, Wharton & Down).
„ W. O. Callender (Callender & Sons).
„ Drake (Drake & Gorham).
Sir Daniel Cooper.
Mr. W. T. Goolden (W. T. Goolden & Co.)
Major S. Flood Page (Edison and Swan United Electric Light Company).
Messrs. Verity Bros.

Electricity Supply Companies (6).

Major-General Webber (Chelsea Electric Supply Company).
The Earl of Crawford (London Electrical Supply Corporation).
Mr. J. E. H. Gordon (Whitehall Electric Light Company).
„ R. Wallace (Kensington Court Electric Light Company).
„ M. Parker (Chatham, Rochester and District Electric Light Company).
„ R. S. Erskine (Kensington Court Electric Light Company).

Consulting Electrical Engineers (4).

Mr. W. H. Preece.
„ G. Kapp.
Mr. H. Sherley Price.
„ W. H. Snell.

General (2).

Sir David Salomons.
Mr. M. Heaphy.

Mr. Crompton was then unanimously elected as Chairman of the Section, and on a ballot being taken the Earl of Crawford and Major Flood Page were elected vice-chairmen.

It was resolved that the meetings of the committee should be held on the first Monday in each month at 3 p.m. Some other business having been transacted the committee adjourned.

AMERICAN NOTES.

By DAS TELEPHON.

I HEREWITH send you the sections of the Act of Congress, now the law, which are of the most importance to owners of submarine cables. The entire Act will follow shortly :—

"Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled: That any person who shall wilfully and *wrongfully* break or injure, or attempt to break or injure, or who shall in any manner procure, counsel, aid, abet, or be accessory to such breaking or injury, or attempt to break or injure, a submarine cable, in such manner as to interrupt or embarrass, in whole or in part, telegraphic communication, shall be guilty of a misdemeanour, and, on conviction thereof, shall be liable to imprisonment for a term not exceeding two years, or to a fine not exceeding five thousand dollars, or to both fine and imprisonment, at the discretion of the Court.

"*Sec.* 2.—That any person who by culpable negligence shall break or injure a submarine cable in such manner as to interrupt or embarrass, in whole or in part, telegraphic communication, shall be guilty of a misdemeanour, and, on conviction thereof, shall be liable to imprisonment for a term not exceeding three months, or to a fine not exceeding five hundred dollars, or to both fine and imprisonment, at the discretion of the Court.

"*Sec.* 3.—That the provisions of the foregoing sections shall not apply to a person who breaks or injures a cable in an effort to save the life or limb of himself or of any other person, or to save his own or any other vessel: *Provided*, That he takes reasonable precautions to avoid such breaking or injury.

"*Sec.* 4.—That the master of any vessel which, while engaged in laying or repairing submarine cables, shall fail to observe the rules concerning signals that have been or shall hereafter be adopted by the parties to the convention with a view to preventing collisions at sea; or the master of any vessel that, perceiving, or being able to perceive, the said signals displayed upon a telegraph ship engaged in repairing a cable, shall not withdraw to or keep at a distance of at least one nautical mile; or the master of any vessel that seeing, or being able to see, buoys intended to mark the position of a cable when being laid or when out of order or broken, shall not keep at a distance of at least a quarter of a nautical mile, shall be guilty of a misdemeanour, and, on conviction thereof, shall be liable to imprisonment for a term not exceeding one month, or to a fine of not exceeding five hundred dollars.

"*Sec.* 5.—That the master of any fishing vessel who shall not keep his implements or nets at a distance of at least one nautical mile from a vessel engaged in laying or repairing a cable, or the master of any fishing vessel who shall not keep his implements or nets at a distance of at least a quarter of a nautical mile from a buoy or buoys intended to mark the position of a cable when being laid or when out of order or broken, shall be guilty of a misdemeanour, and, on conviction thereof, shall be liable to imprisonment for a term not exceeding 10 days, or to a fine not exceeding 250 dollars, or to both."

I also send you the report of the council on the Judiciary of the House of Representation in favour of a Bill to establish "a Court of Patent Appeals." The jurisdiction of the Court is very explicitly set forth in the following sections of the Bill:—

"*Sec.* 14.—That the Court of Patent Appeals of the United States shall have appellate jurisdiction in the cases hereafter specifically provided for, without regard to the sum in controversy:—

"First. From the Circuit Courts of the United States, and from the Supreme Court of the District of Columbia, in all cases touching patents, copyrights, trade-marks, and labels.

"Second. From the Commissioner of Patents in all cases touching the patentability of inventions, priority of invention among several claimants for patent upon the same invention, and the judicial practice of the Patent Office; also all cases touching the registration of trade-marks or labels, and the rights of conflicting claimants therefor."

These provisions of the Bill have received a written approval of several of the justices of the Supreme Court of the United States. Applicants for patents may feel assured that their inventions will receive a just and equitable examination, and that they will not be subjected to the acts of ignorant examiners nor to the whims of Commissioners of Patents, both of which have been faithfully exposed in my "Notes." I send you herewith the entire Bill, so that you may make it public for the benefit of inventors who may desire to obtain patents in the United States.

In regard to the increase of the Commercial Cable stock to $10,000,000, Vice-President De Castro says:—"The capital expended in building and laying the Commercial Cables amounted to over ten millions of dollars, and only six millions of stock was issued. The idea is now to take up the outstanding bonds as fast as they mature, and probably to anticipate the maturity of a part of them and replace them with stock. Up to the present time, six hundred thousand dollars have been retired."

Although large telescopes and tall chimneys are not necessarily intimately connected with electrical matters, yet they both may be, for who knows what will happen in the distant or near future. Well, we Yankees have the tallest monument in the world, and we are about completing the tallest smoke-chimney in the world; it is in process of erection in Newark, about 15 miles from New York. Its diameter at the base is 28 feet, at the top 9 feet, a cast iron rim supporting a ball surmounts the chimney, making the total altitude of the structure 335 feet. One million seven hundred thousand bricks were used in its construction, and it cost eighty-five thousand dollars.

Another big thing is about to be brought out in this country of big and of little things. The latest project comes from California. It seems that Southern California is jealous of its upper half, and is determined to have a telescope of much greater magnifying power than the famous Lick telescope—a gift from millionaire Lick to San Francisco.

The new telescope is to have a 40-inch lens, which will make the moon appear as large as it would be to the unassisted eye if only sixty miles distant; it is estimated to cost one hundred thousand dollars. Doubtless, when that telescope shall be completed, it will be definitely determined whether the moon is made of green cheese. In telephonic matters I have nothing new, except that the Bell people are blowing their trumpet of defiance at telephones which operate on the make-and-break principle, by spreading far and wide that Bell's patent covers that principle, as well as the undulatory current in a closed circuit principle; this is a bugaboo to frighten timid souls.

ELECTRIC LOCOMOTIVE AT BIRMINGHAM.

THE adoption of electric traction by the Birmingham Central Tramway Company was publicly inaugurated on Wednesday (November 7th), when a large number of gentlemen interested in the subject were taken from Station Street to the Moseley depôt and back in a car drawn by the first electric locomotive constructed to the order of the company. This locomotive is supplied by the Julien Electric Company, and is adopted at Birmingham in preference to the self-contained car, simply as a matter of necessity—at any rate, for the present—one object in view being the use of electricity in the place of steam in drawing the existing cars, without any alteration whatever, up any gradient that could be surmounted by the power displaced, and particularly up Bradford Street, where the incline is 1 in 17, which has been regarded by many engineers as an insuperable barrier to the employment of electricity along that route. Further, it was required that the cost of traction and depreciation should compare favourably with steam locomotion—not necessarily that it should be less, but that any extra cost should not be disproportionate to the improvement gained in the way of comfort, cleanliness, and otherwise. Another condition was that the electric locomotive should be able to perform a full day's work of 60 miles without re-charge. The accumulators being arranged so as to be discharged proportionately to the speed or power required, the electric engine is able to mount any gradient that could be accomplished with steam. In appearance the Julien engine is neater and more compact than anything of the kind we have previously seen, the accumulators and motor being trimly boxed in, with nothing left visible but the handle of the switch with which the driver regulates the current. At the Moseley end of the trial trip the managing director of the company, Mr. Smith, explained the views of the Tramway Company, and acknowledged the valuable services rendered by the firm of Elwell-Parker in overcoming the difficulties which presented themselves. Mr. Parker, who was present, stated that the motor was specially designed for the work, and is capable of affording 40 H.P., and that the actual demand upon it in mounting the steepest gradient is about 30 H.P. Some trouble had been caused by an attempt being made to use chain gearing, which gave way under the strain, and was abandoned in favour of a gearing with helical wheels, which is found to work most satisfactorily. Representatives of the Birmingham Town Council, and of neighbouring local authorities, expressed gratification at the result of the day's proceedings, and the prospect of the early removal from the tram routes of the steam engines at present in use. There are no less than 74 of these now running on the Birmingham Central Tramway Company's system, all of them unsightly, and giving off products of combustion disagreeable and unwholesome to outside passengers, and deleterious to the atmosphere of the streets. We shall be glad to learn that the results of further trials will bring about the general adoption of electric traction in place of steam.

THE GROSVENOR GALLERY CENTRAL STATION.

THE central station at the Grosvenor Gallery was thrown open on Wednesday night to the inspection of representatives of the technical Press, about a dozen of whom, together with Sir Coutts Lindsay, Major Waller, and other gentlemen connected with the London Electric Supply Company, were conducted over the various departments of the station by Mr. Ferranti and his assistants. The limited space at our command so late in the week prevents us from describing in full detail all that was to be seen in the vaults—crowded, though capacious—beneath the Grosvenor Gallery. At the outset, however, and before entering upon an enumeration of the machinery, we may state that the directors of the company made ample provision for the creature comfort of their visitors during the midnight prowl.

The history of the Grosvenor Gallery station must be well known to our readers, so it will be sufficient to say that the present plant has been running since the early part of 1887, one dynamo having been started in February and the other in July of that year. The change of plant was not carried out without difficulty, the lighting having to be maintained night and day without intermission.

Dealing first with the boilers, we are informed that these are not situated in the Grosvenor Gallery buildings, although they are connected with the engine-house by means of an underground passage. There are four Babcock and Wilcox water-tube boilers, originally put in for 600 H.P., but frequently worked at double that power in a perfectly satisfactory manner. For the particular class of work to which they are here applied, the Grosvenor Gallery people consider that these boilers far surpass all others in the ease with which a large amount of steam can be generated at very short notice. The gases from the boilers are led into an underground flue, 6 feet by 4 feet, which opens into a chimney stack 80 feet high, with an inside area of 36 square feet. The floor of the engine-room is about 28 feet below the street level. Three Marshall engines are here fixed, these forming the original plant; two are single engines, each capable of developing 200 H.P., and the third is a coupled engine, capable of developing 450 H.P. A Corliss engine, by Hick, Hargreaves & Co., of Bolton, to indicate 750 H.P., was put down in February, 1887. These engines are supplied with steam at a pressure of 120 lbs. to the square inch. Considerable difficulty was experienced in erecting the various steam pipes, on account of the confined space. The three Marshall engines drive on to a countershaft by means of three belts, two of them 24 inches, and the other 31 inches wide, the latter being on the coupled engine. On part of this countershaft is fixed a Ferranti dynamo. An arrangement of specially designed clutches is fixed on the countershaft, which enables the dynamo to be driven by either of the three engines. Another dynamo, identical with the first, is driven from the Corliss engine by means of 17 ropes, 5 inches in circumference. The governors of the Marshall engine are of the Hartnell type, and the method of regulation employed is the adjustment of these governors by means of a sliding weight.

The dynamos are constructed to give probably a larger output than any other machines. They were originally designed for 10,000 lamps of 10 C.P., but they have at times been worked perfectly satisfactorily up to 19,000. The E.M.F. of the dynamos is 2,400 volts, and the maximum current they can supply safely is about 240 ampères. The armatures are 8 feet 6 inches in diameter, and consist of 40 bobbins, wound with copper strip, half an inch wide. These bobbins are connected in two series of 20, so as to bring the points with greatest difference of potential diametrically opposite on the armature. There are 80 field magnets, connected 8 in parallel and 10 in series, and the exciting current is 108 ampères. The dynamos work at 260 revolutions a minute. The framing of the field magnets is constructed in four parts, each quarter weighing 4¼ tons. The armatures weigh approximately 30 cwt. The weight of the pulley and shaft is about 4½ tons. The machine connected by rope gearing to the Corliss engine rests on a bed-plate weighing 13 tons. The shafts are mounted on swivel bearings, so as to stand sudden and unequal strains without placing undue pressure on the brass surface. The exciting machines for the big dynamos are two large Siemens machines, which furnish an exciting current of 108 ampères, at 90 volts. There is also a small Kapp dynamo connected to an Allen high-speed engine, capable of giving 120 ampères and 100 volts. By a system of switches this machine can easily be made to excite either of the large dynamos in the case of failure of either of the regular exciters. Ordinarily, it is used to light the engine-room when the large engines are not running. Connected to each of the main dynamos is a small converter, which runs pilot lamps in the engine-rooms, and to which the voltmeters by which the speed is regulated are fixed.

From the dynamos the current is led at an E.M.F. of 2,400 volts to a main switchboard on which are five switches of a special construction which have 4 feet of break. These switches are used for transferring the five main circuits from one dynamo to the other when necessary. From the switches the current is led to a fuse board of special construction arranged to give a 2 feet break in the circuit when the fuse fails. The fuses are made of a number of strands of tin wire of about No. 30 gauge. They are fitted on plugs with ebonite handles, so that they can easily be taken out of and put in circuit. The leads are then led from the fuse board in a very substantial casing to a main distributing pole on the roof of the Grosvenor Gallery, which, being a fairly high building, gives great facility for clearing neighbouring poles in all directions. The size of the leads in all the main work is 19/15; there are just 100 miles of wire employed, going and returning; the circuits, of which there are five, embracing an area of which the Marble Arch and the Oxford Music Hall, east and west, and Dorset Square and the Strand north and south, are the extreme points. There is an underground circuit running down the Green Park from Hyde Park Corner, lighting Mr. W. H. Smith's residence in Grosvenor Place. The lead and return wires overhead are run 1 foot apart.

The cables are specially made for the company by the Silvertown Company, and have a very high insulation, consisting of pure rubber and vulcanised rubber, served over with stout braid. The spans are suspended from steel wires, 7/16, by means of leather thongs about 8 inches long and ¾ inch wide. The suspender is run in separate spans between the poles, and is insulated at every pole. The poles themselves are ordinary iron tubes, 3⅜ inches in external diameter. The difficulty in obtaining way leaves has not, considering the neighbourhood in which the circuit is erected, been so great as might have been anticipated. The wires laid down to the customer's houses from the main wire are, in some cases, 7/16 cable, and in cases of small installations, 7/20. The wires are chased into the wall right down the whole height of the house, and are enclosed in earthenware pipes, cemented into this chase. Directly the high-tension current circuit is taken into the house the ends of it are connected to a main fuse, as little wire as possible being brought inside the house which is not protected by this fuse. The fuses are double-pole, arranged on earthenware bases. The wires are then led to the switch in the primary circuit, which gives the customer complete control over his circuit. From the switch the wires are led to the transformers, which are of the Ferranti type. These are made to reduce the tension of the current to either 100 volts or 50 volts, according to the requirement. To the secondary terminals is connected one of Mr. Ferranti's alternating current meters.

At the meter the responsibility of the company ceases; the wires in the customer's house, being his own property, are maintained by him. The installations must in all cases be inspected by the company's engineers for their own satisfaction, and the contractors who work on the Grosvenor circuits have a list of rules to which they are obliged to conform.

The maximum number of lamps connected to the system is now about 35,000, but it is found that on no occasion are more than 20,000 employed at any one time, the heaviest hours at the present time of year being from 4.30 to 8.30. The customers supplied being of a very varied class, the load is much better distributed with regard to time than might be supposed. There are very few arc lamps on the circuit; a few photographers in Regent Street and Bond Street employ large projectors for portraiture. Accurate readings are taken of the current supplied by the dynamos every half-hour throughout the twenty-four hours. These measurements are taken on two of Sir William Thomson's ampère balances. The results are plotted on a curve every day of the week, and these curves show accurately the amount of the supply and the nature of the work done.

The transformers are made in five sizes, 2½ H.P., 5 H.P., 10 H.P., 15 H.P. and 20 H.P. In cases where a large number of lights are used, say 1,000, it has been found preferable to instal several small transformers rather than one big one for ease of transport and also for greater security in case of breakdown. As a matter of fact, however, the breakdowns of the transformers have been exceedingly small.

These are briefly the facts which were laid before the visitors to the station on Wednesday evening. We may at some early date be in a position to go into much greater detail regarding this, one of the most interesting, as it is one of the most important, enterprises having the supply of electricity for their object. It may be of interest to mention that an experiment was made of running a 10,000-volt current through 100 100-volt lamps, arranged in series.

NOTES.

Otley and the Electric Light.—As the Otley Local Board is making enquiries with the view of seeing whether the surplus water-power at Ellar Gill can be applied economically to the lighting of the public streets, the members recently inspected the Victoria Printing Works of William Walker and Sons, of Otley, which are now lighted by electricity in all the departments. The installation consists of a 300-light dynamo, serving a large number of glow lamps, and three arc lamps of 3,000 candle-power each. The inspection by the board appeared to give encouragement to the members. The entire plant has been fixed by Messrs. John Roper & Co., of Bradford.

Electric Light at the Mansion House.—At the last meeting of the Court of Common Council, Mr. Judd moved:—"That it be referred to the General Purposes Committee to consider the best means of lighting the Mansion House by the electric light, to obtain tenders and estimates for the necessary work, and to submit them to this court, and that for this purpose the committee be authorised to expend a sum not exceeding twenty guineas." The motion was adopted, with a protest from Mr. Morton against the twenty guineas.

Electric Light on the Stage.—What is described as an amusing scene was witnessed a few evenings since at the Palais Royal, Paris, while the first Act of "Parfum" was being performed. At the moment that Madame Céline Chaumont was about to come on the stage, the electric light suddenly went out, plunging the stage and theatre into darkness. A dim light from another source permitted the audience to see three shadows on the stage, Madame Chaumont and MM. Daubray and Huguenet. After 12 or 15 minutes' waiting the light again appeared and the piece continued. Chaumont then said to Daubray, "Oh, how easy it is to see you now"? Everyone laughed at this *apropos* speech.

Electric Lighting at Hastings.—At the last meeting of the Hastings Town Council, the special committee appointed to consider the question of public lighting recommended that the existing contract with the electric light company for the lighting of the front line from the Queen's Hotel to Warrior Square by 15 2,000 nominal C.P. arc lamps, for £450 per annum, should be renewed from November 26th for another year, subject to the company substituting lamps of the new pattern where not already done. Councillor Jenner moved the adoption of the report, although he had not been a very ardent supporter of the electric light. It was, in his opinion, a very expensive luxury, but it had got such a hold on some people that the Council would have great difficulty in shaking it off. Councillor Revill, who seconded the proposition, expressed his opinion that the light was conducive to bringing visitors into the town. In reply to a calculation that the light really cost £570 a year, Councillor Duke said that it was ascertained last year, on comparing the cost of the electric light with Whitehall gas lamps, that the extra cost for the former was only about £150 per annum. Such a small augmentation was thoroughly justified considering the attraction the light was to the visitors. The electric light was being used more and more, and as last year the company paid a dividend, there was reason to hope that they might before long obtain some reduction. Other speakers also supported the electric light, but Councillor Hutchings protested against the "lavish expenditure." The resolution was, however, carried with only one dissentient.

The Electric Light at Eastbourne.—Eastbourne has been officially visited by the members, officials, and medical staff of the Kensington Vestry, to inspect and report upon the working of the electric light, now adopted by the Eastbourne Corporation for the sea front and municipal buildings. The Mayor (Alderman Boulton) welcomed the London visitors at a public luncheon, where Eastbourne was highly spoken of for its superior system of lighting, water, drainage, and sanitary arrangements, which were explained to the visitors by members of the corporation and others. The town is now illuminated with over 1,700 electric lights.

St. George's and the Electric Light.—At a meeting of the George's (Hanover Square) Committee of Works, on Tuesday morning, a discussion arose with regard to the lighting of some parts of the parish, and, in the course of it, Mr. Adkins said that, as a member of the Electric Lighting Committee, he might state that negotiations were taking place with companies with a view to having a considerable portion of the parish lighted by means of electricity.

The Electric Light at Blenheim Palace.—The interior of Blenheim Palace is now brilliantly illuminated by the electric light.

Swansea and the Electric Light.—The Corporation of Swansea is advertising its intention to apply to the Board of Trade for a Provisional Order under the Electric Lighting Acts of 1882 and 1888.

Ipswich and the Electric Light.—At the last meeting of the Committee of the Ipswich Town Council having the electric lighting question under consideration, the Town Clerk reported that he had laid before the Council Messrs. Paris and Scott's application for permission to lay electric lighting mains under the footway in the main streets of the borough. The Council was decidedly adverse to the proposal, and suggested, what was first suggested in that committee, that the parties should apply for a Provisional Order or licence under the Electric Lighting Act. He said:—"In my opinion the only safe course, and the one which would be found the cheapest and most satisfactory in the end, would be to apply for a Provisional Order under the Electric Lighting Act." The Mayor: That would not give them a monopoly? The Town Clerk: That depends upon the terms of the Provisional Order, but I think the Board of Trade would never give a monopoly. There are legal difficulties in attempting to carry out, without the aid of Parliament, what Parliament has provided for by Provisional Orders. The Town Clerk was directed to lay the matter before the Council at the next meeting.

New York Electrical Society.—The New York Electrical Society, the electrical section of the American Institute, has organised a course of lectures for the coming season, in which a number of prominent electricians will appear before the society. On the invitation of Mr. Thomas A. Edison the first of these will be held in the Lecture Hall of the Edison Laboratory, at Orange, N.J., on Wednesday evening, October 24th, when Mr. A. E. Kennelly will deliver a lecture on "Electrical Measurement," accompanied by experimental demonstrations. After the lecture Mr. Edison's library and electrical laboratory will be open to inspection, thus affording an opportunity of examining one of the finest collections of electrical books and apparatus in the world.

Electric Lighting in Birmingham.—At the meeting of the Town Council to-day, Friday, the General Purposes Committee will report on the notice given by Messrs. Chamberlain and Hookham of their intention to apply to the Board of Trade for a provisional order, to be confirmed by Parliament next session, empowering them to "supply electricity for public and private purposes within the area in the jurisdiction of the Council." The question for the Council will be whether they shall or shall not consent to the application. In case of consent being given, the application would of course be unopposed. It is understood that the General Purposes Committee will report that in their opinion consent should be withheld, and that the subject should be postponed for future consideration. The grounds of the recommendation, we believe, are that the committee were not satisfied with the terms of the proposed provisional order, and have received the suggested alterations of the terms at a period too late to allow of their being duly considered before the time for application. The committee will also, it is said, assign as a further reason for postponement that it may be desirable for the Council itself, as the local authority, to obtain a provisional order, and under its terms to grant licenses to persons who are desirous of supplying the electric light. The effect of the report would, of course, be to postpone the matter for twelve months longer; but it would still be within the power of the proposed undertakers to apply to the Board of Trade for an order without the consent of the Council.

Electric Light in an Observatory.—At Monday's meeting of the French Academy of Sciences, M. de Lacaze-Duthiers thanked that body for the assistance it had lent him in the installation of the electric light at the observatory of Banyuls. Thanks to the improvement, the animals in the aquarium were now shown and lighted up in a magnificent manner, which allowed of the principal organs of the transparent animals being seen.

Paris and the Electric Light.—The Paris Municipal Electric Lighting Stations.—The 25th and 26th of October were the dates fixed for opening the tenders for the steam and electrical plant required in this installation. Eight firms have tendered for the electrical plant, viz., La Société Continentale Edison; La Société Lyonnaise; La Société Alsacienne; La Société d'Eclairage Electrique Jablochkoff; M. Patin, the representative of Mr. Ferranti; M. Victor Popp, the representative of the Thomson-Houston Company, and M. Cuenod-Sautter. After inspecting the tenders of these parties, a sub-committee, under the presidency of M. Mascart, was formed, and instructed to examine the rival schemes in detail, and recommend one for adoption. The final decision, *Industries* states, will take place in about six weeks.

Gas Companies and Electric Lighting.—The fittings of the electric department of the Alliance Gas Company in the new premises alongside the Leinster Hall, Dublin, are rapidly approaching completion. Four engines with a suitable number of dynamos have been erected, the engines being the make of Robey, of Lincoln, and the same as were used by the old electric light company of Dublin, which was wound up in 1883. Two of these are at present employed in the production of the electric light which is now supplied by the Alliance Company to Messrs. Pim's establishments in the South City Markets and North Great George's Street, this firm using 30 arc lamps and 50 incandescent lights. Messrs. Clery & Co. are using five arc lamps supplied from the same source, and several applications for the electric light are in the hands of the Alliance Company from large houses in the city, which will be attended to as soon as possible. The wires run overhead from Hawkins Street, and we understand that it is not intended to have any of these running underground in the streets. The remaining two engines will, it is expected, be at work in a couple of weeks, when the establishment will have 140 horse-power, this being thought sufficient for any possible requirements from city warehouses and shops for some time to come.

Telephony in the North.—The Northern District Telephone Company opened its exchange in Middlesbro' in December, 1885; the number of subscribers on the Post Office exchange in that town being then 34. The telephone company has at the present time over 100 subscribers, and the Post Office 30. In the two Hartlepools exchange, which was opened by the company in January, 1886, they have at the present time 70 subscribers; while the number of the Post Office renters are 26, being the same as it was when the company first commenced operations in these towns. In Sunderland the company, in the year 1886, had 198 subscribers, and the Post Office 54. The numbers at the present time are as follows:—The company, 330 subscribers; Post Office, 42; 16 of the latter number being also members of the company's exchange.

New Centres.—The Northern District Telephone Company has opened exchanges in the following towns, viz., Wallsend-on-Tyne and Linthorpe. Exchanges will also be shortly opened in Alnwick, Berwick, Redcar, Saltburn, and Jesmond. The trunk line to Redcar and Saltburn is already constructed, and messages are being daily sent from these towns over the whole company's system, in some cases a distance of 90 miles.

Telegraph Extension in Scotland.—A large and enthusiastic meeting of the people of Plockton was held on Wednesday last week to consider the desirability of having telegraphic communication extended to this important village. Replies to correspondence, addressed by private gentlemen to the Surveyor-General anent the amount of guarantee, &c., required, having been read, the meeting unanimously came to the resolution to use every possible endeavour to obtain the much needed extension of telegraph.

Mr. Magnus Volk and the Sultan of Turkey.—Intelligence has been received at Brighton of the reception by the Sultan at Constantinople of Mr. Magnus Volk, who journeyed thither with his electric dogcart for exhibition before the Court. A trial of the new vehicle came off with great success in the palace grounds, and the Sultan was so highly delighted with what he had seen, that he conferred upon his electrical visitor a scientific decoration. It is also stated that Mr. Volk's opinion has been taken regarding the desirability of introducing the electric light into Constantinople for the purposes of public illumination. With the hearty support of the supreme ruler of Turkey, Mr. Volk will experience none of the opposition with which he had to contend in Brighton.

Death from an Electric Shock.—Early on Saturday morning a man named Edward Atkinson Richardson met his death at Consett Ironworks, in the county of Durham. It appears that a couple of wires connected with the electric light had got out of order, and Richardson left the engine house, where he was in charge, with the intention of remedying the defect, and nothing more was seen of him until he was found lying at the foot of the boiler bed, about nine feet from the spot where he had been engaged upon repairs. The man was unconscious when he was found, and two hours afterwards he expired at Consett Infirmary. The deceased, when he went to examine the electric wires, was not wearing the gloves provided for the purpose, and it is thought that he had stumbled and received an electric shock. Can any of our readers tell us what system is adopted in these works?

Bursting of a Reservoir.—A telegram from Geneva states that the water reservoir at Montreux, for the service of the electric railway, has burst. Several houses were swept away by the rush of escaping water, and ten persons are known to have perished.

Award of Merit.—The Electrical Power Storage Company has been awarded a gold medal at the Brussels Exhibition.

American Machinery and Tools.—A new edition of their catalogue has just been issued by Messrs. Charles Churchill & Co., who have for the past twenty-five years been engaged in introducing to English users the machinery and tools found to be best suited to their needs. Among the special features of the list are some new milling machines by the Brainard Milling Machine Company; new pattern screw-cutting engine lathes, by Flather & Co., recommended for extreme accuracy; blowers, fans, and exhausters, by Sturtevant; lubricators, indicators, and valves, by the Crossley Steam Gauge Company; and the twist drills made by Smith and Coventry, for which Messrs. C. Churchill & Co. are the London agents. Prices and particulars are also given of the "Excelsior" raw hide belting, which is made from leather manufactured expressly for belting by a process which retains all the strength of the raw hide, and does not in any way weaken or injure the fibre, the leather thus produced being, it is said, far better adapted for belting than ordinary tanned leather. These belts are specially recommended for use on electrical and other high-speed machinery. The catalogue is beautifully printed by Goldie, of Glasgow.

Exhibition and Sale of Inventions.—Under the title of the Inventors' Exhibition and Sales Rooms, Limited, a company has been formed, with Mr. S. J. Mackie as its managing director, the object of which is to afford inventors the opportunity of publicly exhibiting their productions and to effect sales to the trades and the public. For this purpose rooms have been taken at 27, Chancery Lane, which were on Wednesday inspected by a large number of members and visitors, on the occasion of the first *soirée* of the present season. The great attraction of the evening was the reading of a paper by Colonel Gouraud on Edison's phonograph, illustrated by the latest instruments.

An Electric Light Plant Stolen.—While an investigation was being made to ascertain the amount of lead pipe stolen by a gang of thieves from the building at 22nd and Chestnut Streets, until recently used by the cyclorama of the battle of Missionary Ridge, it was accidently found out that the engine, boiler and electric light plant formerly used in the building had been taken away. The value of the plant amounted to several thousand dollars, and detectives are at work trying to discover what has become of it.

Sugar Refining by Electricity.—We have *heard* a good deal about sugar being refined by electricity, says *Modern Light and Heat*, now what we want to find is the man who has *seen* sugar refined by electricity, and is intelligent enough to be sure that electricity is the refining agency, and not simply an adroitly used factor in a mechanical process for extracting dollars from pocketbooks.

Swinton-Cox-Walker Magneto Bells.—In commenting upon the fact that the November part of *Chambers's Journal*, and also of *Cassell's Magazine*, contain appreciative notices of the new Swinton-Cox-Walker magneto electric bells, the *Northern Echo* says:—It is gratifying to find a North countryman's work so well to the fore in this mystic science, and, in fact, pioneering a new branch of it; and we believe we are correct in adding that Mr. Cox-Walker is by no means satisfied with what he, in conjunction with his coadjutor in this matter, Mr. Swinton, has already accomplished, but that he is pushing his experiments further, and has now succeeded in producing thoroughly good and reliable signalling bells of larger dimensions—that is, such as are required on railways and in mines.

Personal.—Mr. Allan V. Garratt, who for some time has been connected in an editorial capacity with *Modern Light and Heat*, a smart electrical paper, published in Boston, has been appointed secretary and treasurer of the National Light Association. He, therefore, relinquishes journalism.

Mr. H. C. Davis, who recently visited this country, has retired from the presidency of the Sawyer-Man Electric Company, to devote his time chiefly to managing the large estate left by his father. For nearly four years Mr. Davis has been at the head of the Sawyer-Man Company, and by his ability, great industry, and the strictest integrity has won a conspicuous and enviable position in electric lighting circles.

Society of Arts.—The one hundred and thirty-fifth session will commence on Wednesday, the 21st November, with an opening address by the Duke of Abercorn, C.B., Chairman of the Council. At the first ordinary meeting of the society a paper will be read by Colonel Gouraud, on "The Phonograph." This will be followed by one by Mr. Henry Edmunds, on "The Graphophone." At the other two meetings to be held before Christmas the papers will be by Mr. W. H. Deering on "Explosives," and by Mr. W. J. Dibdin, on "Standards of Light." Among the papers announced for the latter part of the session we notice "Secondary Batteries," by Mr. W. H. Preece, F.R.S.

NEW COMPANIES REGISTERED.

Humboldt Electric Power and Mining Company, Limited.—Capital £82,500, in £1 shares. Objects:—To carry on mining operations in Nevada, U.S.A., or elsewhere, and to sell or lease the property, water rights, and electric power, or other properties required. To construct railways, electric machinery and wires, railways, tramways, &c. Signatories (with 1 share each):—J. F. Nivan, 2, Colchester Street, S.W.; Frank Fuller, Belmont, Queen's Road, Leytonstone; E. J. Jameson, 111, Bushey Hill Road, S.E.; C. S. Bensted, 156, Stanstead Road, Forest Hill; Hy. Howard, 88, Warner Road, Camberwell; R. Morgan, 112, Petherton Road, N.; A. R. Hewitt, 15, Shepperton Road, N. The first directors are:—Sir Guyer Hunter, M.P.; George Reid, L. P. Allen, and two others to be appointed after allotment by the board of the Consolidated Esmeralda, Limited. Qualification, 100 shares; remuneration, £100 per annum each, and in addition the board may divide 5 per cent. of the net profits of any year in which 12½ per cent. dividend is paid. Registered 1st inst. by Stretton, Hilliard & Co., 75, Cornhill.

Market Rasen New Lighting Company, Limited.—Capital £4,500, in £10 shares. To take over and continue the business of the Market Rasen Gas Company; also to carry on in the said township or elsewhere the business of an electric lighting company in all branches, and to supply electricity for light, heat, motive power or force, ventilation, sanitation, or for means of communication. Signatories:—*Hy. Bird, 29, Hamilton Road, Ealing, 3 shares; Louis Rhodes, Market Rasen, 5 shares; C. Bond, Winchester Terrace, Newcastle-on-Tyne, 1 share; *M. Searle Barton, 1 share; J. Casterton, 5 shares; J. Wilson, 5 shares; *J. Marriott, 10 shares; H. W. Marriott, 5 shares. The last six are of Market Rasen, Lincoln. The signatories denoted by an asterisk are the first directors. Qualification for subsequent directors, £50 in shares or stock. Registered 2nd inst. by Collyer & Co., 4, Bedford Row.

Manlove, Alliott and Company, Limited.—Capital, £100,000 in £10 shares. Objects: To take over the business and goodwill of Messrs. Manlove, Alliott and Co., of the Bloomsgrove Works, Nottingham, and to carry on the business of mechanical and Colonial, civil, and consulting engineers, electricians, suppliers of electricity for light, heat, motive power, or otherwise, and of manufacturers and dealers in all kind of electrical apparatus. Signatories (with 1 share each): *Edward Manlove, Devonshire House, Buxton; *J. B. Alliott, Nottingham; *J. M. C. Paton, Nottingham; *E. A. Manlove, 50, Queen Victoria Street; T. Cantrell, Nottingham; W. B. Thorpe, Nottingham; Jesse Hind, Nottingham. The signatories denoted by an asterisk are the first directors; qualification, shares upon which £500 has been paid up; the company in general meeting will appoint the remuneration of the board. Registered 5th inst. by R. Jordan, law stationer, as agent for Messrs. Wells and Hind, solicitors, of Nottingham.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Woodhouse and Rawson Electric Contract and Maintenance Company, Limited.—The annual return of this company made up to the 29th ult. was filed on the 31st ult. The nominal capital is £50,000 in £10 shares. 1,008 shares have been allotted, and of these 505 are considered as paid up. Upon 503 shares the sum of £2 per share has been called and paid.

CITY NOTES.

The Eastbourne Electric Light Company, Limited.

An ordinary general meeting of this company was held on Thursday last week. The Mayor (Alderman G. Boulton) was in the chair. The only business was the re-election of the retiring directors, Mr. Alderman G. Boulton and Mr. J. G. Langham.

The Chairman, in the course of a long speech, said the company was started in the year 1882, beginning by starting a few lights on the parades. They now found themselves in a position, at the end of six years, to light up a large portion of the town, as well as numerous private houses and shops. At the present moment they had over 1,700 lamps running. After further remarks, the Chairman proceeded to attack the statements made by Dr. Jeffery at the last annual general meeting of the Eastbourne Gas Company. Dr. Jeffery had, he said, accused the Electric Light Company of raising the price of their light to the public at the time the Gas Company were lowering it, and also of charging more for the arc lamps on the parade than was charged by the purveyors of the Thomson-Houston electric light system. He then quoted a clause of the Eastbourne Gas Company's Act, which laid down that the company should not pay a larger dividend than 10 per cent. on the original capital; the last dividend of the gas company was £12 10s. per cent. If any consumer of gas in the town brought an action against the chairman and directors of the gas company they would not only be bound to reduce their dividend, but bound to repay to every consumer of gas a substantial proportion of the amount overcharged them for their gas. Mr. J. G. Langham and Mr. Hammond having spoken, the retiring directors were re-elected.

Maxim-Weston Electric Company, Limited.

THE directors have issued a circular to the shareholders, in which, after setting forth the proceedings at the extraordinary general meeting of the company, held on October 19th, as stated in the REVIEW for October 26th, they say:—

"The directors have now to report that Mr. Watt's petition came on for hearing before Mr. Justice Chitty on the 27th inst., when by consent the petition was dismissed upon the terms that £500 should be deposited by the company, to abide the result of proceedings to try the respective claims of the company and Mr. Watt. In the event of the company being successful, the £500 will, of course, be repaid to them, together with the costs of the proceedings. Mr. Watt claims under his petition £784 12s. 2d. The company's claim against Mr. Watt amounts to £4,616 10s.

"The directors now call upon the shareholders to redeem their promise to subscribe for shares within seven days of the date of this circular.

"The payments have been arranged so as to put the shareholders to the least possible inconvenience, as follows:—6d. per share on application, 6d. per share on allotment, 6d. per share three months after allotment, 6d. per share six months after allotment, 6d. per share nine months after allotment. At no time in the history of electric lighting has the prospect been so bright as at present, and the directors can only repeat what they have already told the shareholders, that with sufficient working capital there is no reason why the company should not do a good and profitable business."

The West India and Panama Telegraph Company, Limited.—The report of the directors for the half year ended June 30th states that the amount to credit of revenue was £49,965, and the expenses £27,578, leaving a balance of £22,387, which, with the balance of £1,806 brought from last account, made a total of £23,993. Of this sum the directors had placed £2,000 to reserve, leaving an available balance of £21,993, with which it was proposed to deal as follows:—In payment of 12s. per share on account of arrears of dividend on the first preference shares, £20,738; and balance to current half-year's account, £1,255.

The Submarine Cables Trust.—This Trust notifies that the balance of 10s. outstanding on the coupons due on April 15th, 1888, will be paid on and after the 15th inst. by Messrs. Glyn, Mills & Co., Lombard Street. The coupons must be left with the bankers five clear days before calling for payment. It is estimated that the trustees will, on April 15th next, have sufficient money in hand to pay the whole or greater part of the £3 due on the October coupons.

The West India and Panama Telegraph Company, Limited.—The report for the half-year ended June 30th, states that the revenue was £49,965, the available balance being £23,993. The directors have placed £2,000 of this to reserve, and propose a payment of 12s. per share on account of arrears of dividend on the first preference shares, carrying forward £1,255.

The South of England Telephone Company, Limited.—The directors have declared a dividend of 6 per cent. per annum on the preference shares of the company for the half-year ending Octoher 31st, 1888.

TRAFFIC RECEIPTS.

The Cuba Submarine Telegraph Company, Limited. The number of messages passing over the lines of this company during the month of October was 4,210, estimated to produce £3,500, against 3,417 messages, producing £3,024 in the corresponding month of last year. The traffic receipts for the month of July, estimated at £3,100, realised £3,086.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending November 2nd, 1888, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £4,110.

The Eastern Extension, Australasia and China Telegraph Company, Limited. The receipts for the month of October, 1888, amounted to £38,060, compared with £40,018 in the corresponding period of 1887.

The Great Northern Telegraph Company, Limited. The receipts for October, 1888, £23,600; January 1st to 31st October, 1888, £226,200; corresponding months 1887, £220,880; and of 1886, £217,800.

The Eastern Telegraph Company, Limited. The receipts for October, 1888, amounted to £55,742, compared with £53,089 in the corresponding month of last year, an increase of £2,653.

The Direct Spanish Telegraph Company, Limited. The estimated receipts for the month of October were £2,210, against £2,276 in the corresponding period of last year.

The Brazilian Submarine Telegraph Company, Limited. The traffic receipts for the week ending November 2nd, amounted to £4,949.

PROCEEDINGS OF SOCIETIES.

The Society of Telegraph-Engineers and Electricians

AT the ordinary general meeting of this Society, held on Thursday, November 8th, a paper "On Ocean Temperatures in relation to Submarine Cables," by WM. LANT CARPENTER, B.A., B.Sc., Member, was read, of which the following is an abstract:—

In the paper read by Mr. Stallibrass on November 10th, 1887, on "Deep Sea Soundings in connection with Submarine Telegraphy" and in the discussion thereon, no reference was made to temperature sounding, and the influence of temperature upon (1) the conductor, (2) the insulation resistance of cables. Ocean temperatures varied, even in the tropics, from 85° Fah. to 30° Fah. The resistance of a conductor at 85° was 10·8 per cent. greater than at 30°, but the insulation resistance of a cable at 30° was thirty times that at 85°. Calculations and diagrams to show this, founded on data obtained from the Accra-Sierra Leone cable, laid in 1886, and kindly supplied to the author by Mr. Henry D. Wilkinson (Member), were exhibited. All insulating substances were not equally thus affected. The influence of pressure upon insulation resistance was touched on in passing, and the author went on to describe the method of ascertaining temperatures at great depths in the sea. Ordinary self-registering thermometers indicated too high a temperature, the pressure (1 ton per square inch for every 800 fms. depth) contracting the bulbs and forcing the liquid up the stem. This was first successfully obviated in the "Miller-Cassella" thermometer, in which the ordinary bulb was surrounded by a second, the intervening space being partly filled with fluid. The author, under Capt. Calver, in H.M.S. *Porcupine*, had had the first use of these at sea in 1869. Some of them were exhibited, through the kindness of the Hydrographic Department of the Admiralty.

Their indications were controlled also by the Siemens electrical thermometer (exhibited at the meeting), in which two coils of precisely similar construction and equal resistance at the same temperature form the two arms of a Wheatstone bridge; one of these is attached to a cable and lowered into the sea, and the bridge is balanced by altering the temperature of the water in which the other coil is placed on deck, when a thermometric observation of this latter gives the temperature of the submerged coil. Some deep-sea thermometers, contrived and manufactured by Messrs. Negretti and Zambra, were also exhibited, in which the instrument was reversed and the mercurial column thereby detached when the sounding line began to be hauled in.

Mr. Carpenter then made a brief reference to the *Challenger* expedition, which lasted 3½ years, traversed 70,000 miles, and established 362 observing stations, at each of which bottom-temperatures were observed, and he then summarised the work of the U.S. steamer *Tuscarora*, sent out to ascertain the most practicable cable route between the Pacific seaboard of the United States and Japan, in the course of which 483 soundings and bottom-temperature observations were taken. The method of "serial temperature soundings" was then briefly described, by which the relation of temperature to depth was ascertained, and the way in which these results were plotted in "temperature sections" was then explained. Several of these, obtained during the cruise of the *Challenger*, were exhibited. Attention was first called to a section across the North Atlantic, from Madeira, through the Azores and Bermuda, to Halifax. About ⅘rds of this mass of water was seen to be below 40° Fah., the bottom temperature varying from 34°·8 to 38°·7. In the Northern Pacific the bottom was colder, and the volume of water below 40° larger. In the Equatorial Atlantic the bottom was equally cold, and the "bathymetrical isotherm" of 40° came nearer to the surface than elsewhere, so that as the surface was hotter, the fall of temperature relatively to depth was much more rapid.

The thermal conditions of partially land-locked seas was then contrasted with the above; in the Mediterranean no lower temperature than 54° Fah. was met with, although depths of 2,000 fathoms were sounded; while in the Atlantic, a short distance off, at the same depth 36° was met with. Similar instances were given, among them the Red Sea, 71° being (as far as was known) the minimum; the Sulu Sea, in the line of the cable between Singapore and Hong-Kong, where the minimum is 50°·5, even at 2,550 fathoms; 32° to 33° being the temperature at that depth in the Indian Ocean near, the Celebes Sea, and others.

Here were well authenticated facts, and what was the explanation of them? Without going into a general discussion of oceanic physics, for which that was not the place, he would venture to say that the only satisfactory explanation to his mind lay in the idea, as to the truth of which a vast body of evidence might be brought forward, that there was a constant vertical circulation of the waters of the great oceans, due to the differences in specific gravity, caused by differences in temperature; that the upper layers of water were moving from the equator towards the poles, and the lower layers from the poles towards the equator, their movement being affected also by the earth's rotation; that such seas as the Mediterranean, &c., were cut off from this general oceanic circulation by submarine ridges, so that their water at a greater depth than these ridges was perfectly stagnant, and no interchange with the colder water of the great oceans occurred; and finally that the cause of this circulation was probably to be found in the polar cold than the equatorial heat.

Mr. CARPENTER concluded by citing authorities in support of this view, and by very briefly indicating the effect of this circulation upon climate generally.

NOTE ON THE ACTION OF ELECTRIC SPARKS ON MIXTURES OF NITRIC OXIDE WITH HYDROGEN AND OTHER INFLAMMABLE GASES.

By STEPHEN COOKE, F.C.S.

DAVY, in his "Researches on Nitrous Oxide," says:—"I passed a strong electric shock through equal parts of hydrogen and nitrous gas, confined by mercury in a detonating tube, but no inflammation and no perceptible diminution was produced." This statement, which I believe is quite correct, is still found in some of our works on Chemistry (*e.g.*, Gmelin's). And nothing is said about the action of sparks on these gases mixed in other proportions, although Davy, a little further on, says:—"Perhaps, if I had tried many other different proportions of the gases, I should at last had discovered one in which they would have inflamed; for, as will be seen hereafter, nitrous oxide cannot be decomposed by the compound combustible gases, except definite quantities are employed." This paragraph to a great extent anticipates my experiments on this subject.

Henry, however, is less cautious, and in his "Elements of Chemistry" (9th Ed.) he makes the following statements (on what authority I do not know, but he seems to have experimented on the subject himself):—"It [nitric oxide] does not, however, explode with hydrogen *in any proportion, nor with any of the varieties of carburetted hydrogen.*" (The italics are mine.) And, again, "Nitrous gas does not, with hydrogen gas, afford a mixture that can be exploded by the electric spark." Henry's statements, as I shall show immediately, now need modification.

My own experience on this subject may not prove uninteresting. The first mixture used was equal volumes of nitric oxide and hydrogen, this being the most likely proportion to give any result. On passing sparks it was found that there was a pretty rapid contraction of the volume of gas, but no explosion. The gas left after all action was over was one-fourth the original volume. Evidently the change consisted in the reduction of nitric oxide by hydrogen—

$$NO + H_2 = N + H_2O.$$

I then took two volumes of nitric oxide and one volume of hydrogen, and on passing a spark through this mixture a pretty sharp explosion took place; white heavy fumes appeared in the tube, together with red fumes of nitric peroxide; the volume of the original gas diminished about 40 per cent., and the water in the eudiometer became strongly acid. This experiment was made over water. I then added to the residue a volume of hydrogen equal to that originally employed, and on passing a spark there was a prompt explosion. In this case no fumes (white or red) were formed.

Being busy at the time, I only made a few rough experiments, and at that time I thought the change in the first explosion consisted, for the most part, in reducing the nitric oxide to nitrous oxide, and this appeared somewhat probable, as the first explosion took place with some difficulty, sometimes requiring several sparks, while in the second stage the inflammation of the gases was easier, and the explosion appeared to have more force.

Returning to the subject some months afterwards, I was unable to get any result at all with similar mixtures of the gases. This appeared somewhat extraordinary, as I used pure nitric oxide in each case (prepared from $FeSO_4$, KNO_3, and H_2SO_4, so as to avoid any trace of nitrous oxide), and everything the same, with the exception of a eudiometer. This new eudiometer had the wires approaching each other within one-eighth of an inch, while the one formerly used was an older pattern (which had been broken in the interval), in which the wires were fully one-third of an inch apart. Being unable to purchase one of the older kind, I made one with the wires about half an inch apart, and then the results were similar to those formerly obtained. Another experience may be mentioned here. During my experiments my own coil, giving an inch spark, got damaged, and being unwilling to wait for its repair, I borrowed another, giving a feebler spark. With this, however, no explosion could be got, although the spark would pass readily enough. This coil was then exchanged for one giving a 4-inch spark, and then there was no difficulty in getting an explosion every time, with the mixture already mentioned; and with the new coil a larger proportion of hydrogen could be used than with my own—a mixture of six volumes of hydrogen and ten volumes of nitric oxide exploding with this coil.

With a diminished pressure of 300 mm. of mercury no explosion was obtained. On replacing the mercury by water the same mixture exploded readily. The carefully-dried gases exploded with equal ease to the undried gases.

Possibly with an increased pressure and greater spark, a higher proportion of hydrogen than that mentioned above might have been used.

As regards the explosion of nitric oxide and hydrogen, therefore, my experience may be summed us as follows:—

1. A spark from a feeble coil gives no explosion.
2. A spark from a larger coil gives no explosion if the wires are too close together.
3. No explosion takes place if the pressure is diminished to the extent of 300 mm. of mercury—less than the atmospheric pressure.
4. No explosion takes place if the hydrogen has a greater proportion to the nitric oxide than 6 : 10.

In connection with 1 and 2, it may be interesting to note that Dixon, in a paper read before the Chemical Society, about a year ago, obtained similar results with mixtures of oxygen and cyanogen gases, results which have been attributed to the greater distributing energy of the longer and more vigorous spark. The initial disturbance in these experiments not only determines the explosions, but influences to a considerable extent the resulting products.

We come now to the gases resulting from the explosions. I may state that my first experiments were made over mercury, and the gases resulting from the explosion were determined. The variation was found so great that only pretty general statements can be made. A number of my late experiments were made over water. A number of experiments were generally made with the same mixture—the gases being mixed in a small gasholder, and transferred to the eudiometer.

As illustrating the variation that may occur under like conditions, I may state that in making some experiments with a mixture of nitrous oxide and hydrogen in the proportion of 2 : 1, the residues were mixed and set aside for further examination. On adding the residues from the third explosion to the two first, red fumes were produced, showing that oxygen had been formed in the one case, and nitrate oxide left undecomposed in the other.

Sometimes, owing to the greater initial disturbance of the spark, the flame passes down the tube with greater rapidity, and the explosion is more energetic than at other times. In such cases red fumes are produced, and oxygen is found in the residue.

If the eudiometer is too narrow the explosion may not travel more than a few inches from the wires, and a series of explosions may be got; but nitric oxide is left undecomposed.

Even in a wide tube the explosion may travel slowly down the tube, especially when near the bottom. In such cases nitric oxide may generally be found in the residual gases. With the apparatus mentioned, I have been able to obtain explosions when the volumes were—

$$H : NO : : 1 : 5.$$

With one volume of hydrogen to ten volumes of nitric oxide no explosion could be obtained. The greatest amount of hydrogen with which I have been able to get an explosion is 6 vols. H to 10 vols. NO. The explosion then occurs with difficulty, and only when the larger coil I have mentioned is used. 2 vols. of H and 5 vols. of NO explode very readily. The greater number of experiments were made with mixtures of H : NO : : 2 : 5, and—

$$H : NO : : 1 : 5.$$

The gases produced by the explosion vary so considerably that a detailed account would be of little value. More than 50 experiments have been made, and in all but four or five free oxygen has been found in the residue; and this occurs with the smallest volume of hydrogen, as well as the greatest, depending more, I believe, on the force of the explosion and the temperature produced than the proportion of gases present. (For instance, 13 experiments were made with the lowest amount of hydrogen, and in 11 of them oxygen was left.) After explosion the residue left was, on the average, about 60 per cent., the extremes being 44 per cent. and 71 per cent.; and here, again, the proportion of gas left often depends more on the nature of the explosion than on the gases present. With two volumes of nitric oxide and one volume of hydrogen, the change may often be approximately represented by the following equation:—

$$2NO + H_2 = H_2O + N_2 + O.$$

The free oxygen is, however, always somewhat less than one-half the amount in the N O; in three cases the volume was determined and the lowest was 40·2 per cent., and the highest a little short of 45 per cent. of the whole—a portion of the NO breaking up as follows:—

$$4NO = 2NO_2 + N.$$

To me the most unlooked-for reaction in these experiments is the production of free oxygen, especially when such a small volume of hydrogen is used.

I have already quoted Henry with reference to the action of hydrocarbons and nitrous oxide. Some hydrocarbons will, however, combine readily enough with NO if submitted to a suitable spark discharge, provided the volume be properly proportioned. Marsh gas, especially, explodes more readily than hydrogen when the volume is not less than one-twentieth or greater than one-eighth of the nitric oxide used. The results show that all the carbon is oxidised to CO_2, and the residue in all my experiments contained free oxygen, this result being accounted for by the vigour of the explosion.

Sulphuretted hydrogen, when mixed with nitric oxide, can be readily exploded.

Carbonic oxide and nitric oxide did not in any proportion explode. There is a gradual combination, however, which may be represented by $NO + CO = CO_2 + N$. — *Glasgow Philosophical Transactions.*

DISCUSSION ON MR. SPRAGUE'S PAPER ON ELECTRIC RAILWAYS.*

THE discussion of Mr. Frank J. Sprague's paper on "The solution of the municipal rapid transit problem" took place before the American Institute of Electrical Engineers, on October 9th at the House of the Civil Engineers, 127, East Twenty-third Street, before a very large gathering of the members. This discussion was opened by Mr. M. B. Leonard, of Richmond, telegraph superintendent of the Chesapeake and Ohio Railroad Company, who read a paper entitled:

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* This paper was published in abstract in the ELECTRICAL REVIEW for August 3rd, 1888.

SOME OBJECTIONS TO THE OVERHEAD CONDUCTOR FOR ELECTRIC RAILWAYS.

Of all the valuable papers read before the Institute probably none has excited greater interest than Mr. Sprague's admirable contribution on "Electric railways, the solution of the municipal rapid transit problem," in which the advantages of electricity in practical operation have been so well set forth as to convince the most sceptical of its superiority over all other methods of traction for this class of traffic. Although the paper was written with special reference to the adaptability of electricity in solving the problem of rapid transit in the great city of New York, the benefits resulting from this system of propulsion may be obtained equally as well elsewhere and prove to be as permanent as we have found them in our historic city of Richmond.

To electrical engineers this comparatively new application of the electric current is one of the most important questions that have come before them, and should be carefully studied in all its details, so that the defects and objections may be pointed out and guarded against and the most perfect methods evolved as speedily and fully as possible. But in working this question out it must be remembered that "the more haste the less speed," and that before undertaking to surpass the locomotive it is wiser to prove its superiority over the horse or mule. Having accomplished this successfully, then it is time to endeavour to rival steam. In attempting what has been aptly described as "feats of sensational engineering," it should always be borne in mind that failure inevitably deals a severe blow to the whole cause of electric traction, the general public not always being inclined to discrimination in such cases, as will be remembered from the accident which occurred to a number of capitalists and prominent people some years ago who were engaged in testing the traction system of a well-known electrician.

A second point of the utmost importance is the necessity for first-class workmanship. Anything worth doing at all is worth doing well, and particularly is this the case with the utilisation of a new force. This is so self-evident as to require no further comment.

While it has been successfully demonstrated in the City of Richmond that electric traction is really the solution of the rapid transit problem, and we have felt in the increased value of real estate and the growth of our city in population and reputation the substantial benefits resulting therefrom, I have considered from my daily observation of the operation of this electric road that the overhead wire system cannot be made a perfect or ideal method of operation under all circumstances because of the defects inherent in such a method. But that it will serve as a pioneer in the new field, and will be supplanted in time by a more perfect system, I have not the least doubt, and in the following remarks I will endeavour to show some of the objections that have come to my notice, although there may be others that have escaped my attention, owing to the extreme reticence of all parties connected with the enterprise, doubtless from business reasons.

Of the three most commonly used, the overhead system appears to be the favourite, the latest report of electric street railways in operation in America showing that out of a total of forty-three not less than thirty-six are using the overhead system, and that at least thirty now under construction have arranged to do so. Doubtless the smaller cost, as compared with the other two, was an important factor in deciding so largely in favour of the overhead conductor.

As used in Richmond, the details of operation have been shown so fully and clearly in Mr. Sprague's paper that it is unnecessary to repeat them here, beyond stating that the rail and earth system is adopted in connection with the overhead wire. During the seven months of active operation of the Richmond Union Passenger Railway many thousands have been successfully transported every day, and at a very much lower cost than could possibly have been done by horse-power, owing to the excessive grades encountered; but the defects of the overhead system are now becoming more apparent as the plant suffers its material depreciation, and we are now in a better position to judge of its value as a permanent institution than we could possibly have done heretofore.

It is an undisputed fact that the encumbering of the streets with the poles required for the overhead system is one of the most serious objections to its use, although they are hid to a large extent in many places by the shade trees and foliage; yet on the main streets of our cities, where this system is most likely to be used, they are not only a grievous eyesore, but also increase the liability to accident from runaway horses and other causes. Their appearance would not perhaps be so offensive were it possible for them to maintain an erect position, but on account of the weight of the trolley wires, and the pressure of the trolley, the tops of the poles are constantly pulled together, notwithstanding they may have at first been raked in the other direction, and thus the unsightly effect is augmented. Those of us who are acquainted with telegraph line construction can appreciate the great leverage exerted by a heavy strain on the top of a pole twenty-five or thirty feet high, unsupported by guys or otherwise, and will readily understand that it is only a question of time before the poles must be reset or replaced with heavier ones. This has been especially the case on the curves where the strains have been greatest, in some instances approximating a pull of 650 pounds; nor does the network of wires, span, trolley, guard, and curve, inspire the public with any feeling of toleration for the disfiguring of its streets, but must hasten the time when the clamour for underground wires will compel their removal.

But to my mind the most serious objection is the employment of the bare trolley wire carrying a current of 500 volts and about 90 ampères, which I consider not only dangerous to life on account of the frequent breakages of the wire, which on one occasion last spring in falling struck and killed a horse, but also in damage to property by fire. It is claimed that the use of guard wires will always prevent the possibilities of such an occurrence, but the guard wires did not obviate the burning and melting of the telephone wires when on one occasion the breaking of an exchange telephone pole threw them across the trolley wire, and it was necessary to shut down the railway to prevent the entire destruction of the exchange and possibly the firing of the subscribers instruments and houses.

That the trolley wire is liable to breakage at any time has been shown twice during the past week to the interruption of travel and dissatisfaction of the public; while not so very long ago the wires over one of the curves were pulled down on top of the car by the trolley catching in it, and travel was entirely suspended on that part of the line for one or two days. A very serious defect in the use of the bare trolley is the difficulty of securing proper insulation. Thus far porcelain knobs seems to have been found best adapted for this purpose, and the leakage resulting, especially in damp or rainy weather, must be considerable on the whole length of the line, and must cause a large waste of current. This is probably the reason why it has been impracticable to run over about thirty cars at one time out of the forty with which the road is equipped, and would seem to indicate a very large loss of energy. In view of the fact that porcelain insulators have been long ago condemned for telegraph purposes where a comparatively small current is used, it seems strange that they should have been adopted as the best means for securing insulation in circuits of such high potential as are employed on the Richmond Road.

The trolley itself seems to be a clear source of trouble and difficult to manage properly. As has been shown, it consists of a grooved wheel at the end of a counter-balanced pole held by a spring against and making contact with the underside of the working conductors. In rounding curves it must be carefully watched by the car conductor to prevent its leaving the trolley wire and thus stopping the car, and at night extinguishing the lamps, which has proved exceedingly disagreable to the passengers, while on busy days it has seemed necessary to put a third man on at each car at additional expense for the sole purpose of attending to the trolley. Sometimes the trolley pole has broken, or the springs holding it against the wire have given way, stopping further progress of the car or requiring a man to stand on the car-roof holding the trolley pole against the wire until the repair sheds were reached.

One of the most unsatisfactory features about the arrangement of the Richmond road is the ground circuit, not only because of the difficulty of getting a good ground, which has, in this case, only been accomplished by connecting the track with the whole gas or water works system of the city to the detriment of our exchange telephone system so well described by the telephone superintendent, Mr. McCluer, in his paper before the recent telephone convention; but the fact is that it is necessary to have a clean track to work on, otherwise vivid flashes of electricity will appear, to the terror of the horses in the vicinity, and damage to the motor; or should it happen that there is a sufficient quantity of dirt on the rail, it will cause a higher resistance than the potential of the current can overcome, and of course stop the car. Should the motor man get off to push it over the dirt and fail, as sometimes happens, to switch off the current from the motor, the full current on the line will pass through it just as soon as a good contact is made, and the result is a burnt armature and a disabled car. This seems to have been particularly the case during the recent stormy weather, when I am informed that the number of available cars for traffic on the road was reduced to about 10. Possibly the saturation of the motor by the rain and the effect of lightning on the trolley wire had also something to do with the case. Owing to the reticence of the *employés* above referred to, it has been difficult to ascertain just what damage has been caused by lightning striking the trolley wires and injuring the motors, but that there has been serious trouble from this source I have no doubt. The very best forms of lightning arresters have not proved sufficient to prevent injury to electric light dynamos where insulated wires are used on the outdoor circuits, while the bare wire used for the working conductors on overhead electric traction systems must always render them more susceptible to trouble from this direction.

After setting forth the difficulties which have been shown in the practical operation of the most extensive system of electric traction in the world, it gives me pleasure to direct attention to the remarkable behaviour of the Sprague motors under all the conditions to which they have been subjected for the past seven months, which has been indeed remarkable. No load has been too heavy and no grade too steep for them to ascend. Perhaps the severest test they ever received was on the night of July 4th in bringing the crowds from the new Reservoir Park when the ordinary open cars carried over 100 passengers and the closed cars over 75 each, so many in fact that the axles of one or two of the cars broke down under the load, all of which must be exceedingly satisfactory to the inventor, and places the Sprague motor at the very head of the many excellent types or forms that have been devised at home and abroad.

The objections referred to above apply equally as well to all forms of overhead systems except where a second wire is used for a return instead of the track and earth, and also where the trolley pole is discarded for the movable trolley. But the increased number of aerial wires required as well as the heavier fixtures needed to sustain them render these systems just as objectionable.

We are very anxious to see the effect of ice, sleet and snow upon the operation of our road, as it has not yet passed through a winter in complete running order. A heavy sleet storm has often prostrated our telegraph lines, and I see no reason why the overhead electric railway wires would be exempted from similar trouble, nor why the covering of the rails by ice and snow will not render it difficult to make a sufficient contact to operate the line successfully, not to speak of the loss of current by leakage or escape from the trolley wires, but I have no doubt that the ingenuity of those who have overcome all the problems encountered in opening up with such success the Richmond Union Passenger Railway will be sufficient to insure its continued operation in spite of wind and weather, and to no one more than myself will this be gratifying, since it was through my efforts that attention was first directed some three or more years ago, to the splendid opportunities for electric traction that Richmond presented, although I am free to confess that my inclinations were towards the application of the storage battery, which obviates all the troubles and defects developed by the overhead systems, and against which no more serious objections seem to be brought than the extra weight caused by the batteries and the greater first cost as compared with the aerial systems, all of which, it appears to me, are more than counterbalanced by the difficulties and annoyances in the systems just described.

The very satisfactory results obtained in the operation of the new electric storage cars on the Fourth Avenue Railroad in this city, as well as by Mr. Wharton in Philadelphia, M. Huber in Hamburg, and elsewhere, prove, as I have believed, the storage battery to be the only ideally perfect system of electric traction for municipal purposes.

The following note by Mr. Almon Robinson, of Lewiston, Me., was then read by the secretary:

NOTE ON GEARING FOR ELECTRIC RAILWAYS.

Probably no one will be disposed to deny that in devising a connection for the motor and the car wheels, what Mr. Sprague attempted to do has been done extremely well. Has he attempted all that is desirable?

Mr. Sprague's investigations have shown that, in street car work, a very large percentage of the whole power used is expended in starting the cars. Now it seems to me that a motor, whose speed has a fixed ratio to that of the car wheels, must work uneconomically when the car is moving slowly, for no amount of skill spent in varying the magnetic circuits can prevent an armature from wasting a current sent through it when it is practically standing still. It would seem, therefore, that wide variations of speed and load would make it necessary at times to weaken the field to an unprofitable extent.

Perhaps, however, Mr. Sprague may be able to show that a properly designed motor will work with a high efficiency in doing anything which he puts upon it in railroading.

But even in that case, there would still remain the extra cost and extra weight of a motor large enough to lift its heaviest load by a dead pull.

To do the hardest part of his work, Mr. Sprague is really using a thing in which he disbelieves—a slow moving motor.

In the storage car problem this matter of weight and bulk and cost becomes the most important element. Here, the present practice is simply the hauling about of 10 men to do by main strength what one man could do by a lever.

The desirability of a variable leverage for the motor has not escaped the attention of experimenters. In Mr. Henry's Kansas City work an arrangement of toothed gearing and clutches was tried. I have never learned whether this particular feature proved a help or a hindrance, nor whether it is in use on the Henry road said to be running at San Diego, Cal. A prominent inventor has expended a good deal of ingenuity on the details of a plan making use of reciprocating friction pawls. Mr. Reckenzaun tried and abandoned a leather covered chain, clamped between two cones in such a way that the diameter of the circle of contact could be varied.

Mr. Van Depoele has suggested, and, I presume, tried a connection having two different speed ratios, in which friction gears were used. For this particular purpose (furnishing a variable speed ratio) I am obliged to confess myself a believer in the possibilities of frictional gearing. For electric railroad work it is certainly under a cloud at present. Those who have used it most, like it least. The eminent engineer who, about a year ago, read a paper before the Institute on "Methods of Gearing," seemed to consider that it had been sent to its last resting place by the experts who tested some of Prof. Fleeming Jenkin's devices.

No one seems to notice that every day and on every railroad this method of transmission gets the roughest possible testing; that every locomotive pulls its train by frictional adhesion; that a rail and driving wheel are neither more nor less than a frictional rack and pinion. When we try to copy the work of the locomotive under other conditions our troubles begin. But no man who has ever seen a freight engine climb a grade has any right to speak with disrespect of frictional gearing.

The real root of all the difficulties with frictional transmission seems to be that the pressure producing adhesion does not vary with the dimensions of the gearing, so that when we reduce the size and increase the speed of the gearing the friction at the journal bearings soon becomes enormous. For light work this is partly obviated by using, instead of metal, some more adhesive material, such as paper, raw hide, &c. But none of these surfaces will stand a pull at all comparable with that on the surface of a locomotive driving wheel.

The most promising methods would appear to be those in which the pressure is prevented from acting across the bearings. This idea is carried out to some extent in the well-known V-grooved gearing, but the unavoidable sliding and grinding of the surfaces makes it impossible to obtain a high duty from it. The idea is more fully carried out in the devices of Sellers, Jenkin, and others. I do not know that anything has been suggested—I certainly cannot suggest anything—which does not leave, for the purpose under consideration, much to be determined by trial. Knowing well the effect which actual trial is apt to have upon untried devices, I cannot blame an engineer who prefers to let well enough alone, if a fixed speed ratio is all that he cares for. But I cannot help thinking that a usable connection, which left the speed of the motor independent of that of the car, would be a valuable acquisition; and that a probability of obtaining it would amply justify further experiments with methods of gearing.

MR. ELIAS E. RIES: It is not often that a paper upon so broad a topic contains so much solid meat within, comparatively speaking, so limited a space, as the one we are here this evening to discuss. Mr. Sprague deserves to be congratulated upon the ability and thoroughness with which he has presented the subject, and I take pleasure in adding what little I can to the discussion of such of its features as it seems to me to require more elucidation. The paper, generally speaking, may be divided into two parts: one dealing purely with the municipal rapid transit problem as determined by the conditions that obtain in New York City, and the other with regard to the construction and operation of ordinary electric street railways. I shall take up the latter phase of the paper first, and then, if time permits, will have a few words to say on the general subject of rapid transit as applied to the requirements of New York City. Mr. Sprague, in his paper, refers to several methods of converting the momentum of a train into useful current, one of these consisting in converting the propelling motor or motors of a train into braking generators when running on a down grade or coming to a stop, and returning the current generated back into the line for the purpose of assisting other motors. This method necessitates raising the counter E.M.F. of the motor until it exceeds the direct E.M.F. of the line, and as this latter is 400 volts or more, it will be apparent that only in a few exceptional cases is the train energy or momentum sufficient to develop in the motor or motors anything above the initial electromotive force for any appreciable length of time. During all this period the energy of the train is simply being expended in overcoming the direct E.M.F., or, in other words, in preventing the entrance of the line current to the motor by developing the 400 volts necessary to oppose it, a result that can be as readily obtained, without the expenditure of this energy, by simply opening the motor circuit. The practical effect of the method referred to will be to partially brake the train, but except in a few extreme cases the line current derives no benefit or assistance therefrom. There is, however, another and more economical method of conserving the surplus energy of a railroad train, which avoids the loss of the bulk of this energy, and at the same time permits of the utilisation of this energy *upon the train itself* at times when it is most required. This method, as developed by me some time ago, consists in the employment of a secondary battery so arranged as to be connected with the motor-circuit whenever, as in stopping, or descending a grade, the connection between the line and the motor is interrupted, and the latter is in condition to generate a current under the influence of the momentum of the train. The battery cells are connected in parallel or multiple series order during the time when they are in circuit with the generating or braking motor, so as to oppose an electromotive force of only a few volts to the charging current, thereby making the movements of the train or car instantly available for charging the battery, this charging process continuing until the speed of the armature has been so reduced by its own braking action upon the train or car, that it is no longer capable of generating the few volts necessary to effect the entrance of its current to the storage battery on the train or car. The current thus reclaimed on descending grades, and coming to stops, is employed to assist in operating the train or car when ascending grades and starting from a position of rest. The battery, or such portion of it as may be set aside for operating the motor or motors, is, of course, discharged at a higher voltage, and can be utilised for electric lighting and all other train purposes to which it may be applicable. It will thus be seen that a twofold effect is obtained, since the surplus energy of the train, which, under existing conditions, is ordinarily wasted, is not only made to stop the train without the use of friction brakes, but the energy consumed in stopping the train is, with the exception of a very slight loss in conversion, &c., almost entirely recovered and turned to useful account. Mr. Sprague has stated, in referring to the operation of the New York elevated railway system, that 59 per cent. of the power expended by the locomotives on a round trip is used in starting, 24 per cent. in lifting, and only 17 per cent. in traction. That means that 83 per cent. of the total power expended upon the elevated railway system in this city is consumed on account of stoppages and grades, of which nothing is recovered, but, on the other hand, the waste is augmented by the use of further steam to apply the brakes. If only one-half, or, say, 40 per cent. of this wasted energy can, by the method above described, be recovered, of which I have not the slightest doubt, the value of electric traction for roads of this character over that at present used will be apparent from this standpoint alone. Another matter of considerable importance is whether one or two motors are most advisable for street car work. I myself am in favour of employing but a single motor directly geared to both axles, and it is the universal opinion of electricians and engineers that in a case of this kind a single large unit is better than two or more smaller ones, and this is especially true in regard to street car motors. A great deal has been said about the difficulty of making satisfactory connection with both axles from a single driving source, but this can be overcome, and I may say I have devised a method of doing this which avoids most of the difficulties heretofore encountered. It is a question, to my mind, whether Mr. Sprague's assertion that independently driven axles necessarily give better track adhesion can be sustained. In fact, it seems to me that the reverse is generally the case. There can be no doubt, as Mr. Sprague states, that independently driven axles will slip until they get the best grip, but it is also known that a slipping wheel or pair of wheels will readily continue doing so under the influence of the acquired impetus and the rotative strain exerted upon them by the motor. However, in ordinary street cars the load is constantly shifting from the forward to the rear axle, and *vice versâ*, due to the lurching of the car and unequal distribution of the weight or load. Therefore, supposing a car to be slightly overcrowded at its rear end, the forward wheels must necessarily slip, and the motor driving them will run light for the time being, leaving the rear motor, which was designed to do but half the total work, to do it all, and subjecting it to an enormous electrical and mechanical strain. I have given this subject considerable attention, and have come to the conclusion that for street cars of ordinary construction the axles should *not* be independently driven, but should be directly connected with each other, preferably through the armature shaft of the motor itself, whose weight is equally borne by both axles. One thing that struck me as very peculiar in connection with the Richmond road, was that an electrical engineer of Mr. Sprague's ability and experience should so utterly abandon all measure of precaution for the safety of his passengers and the public at large as would seem to be indicated by his employment of the track rails and ground as one side of the circuit instead of using a double overhead conductor. This is the more to be wondered at when it is shown by Mr. Sprague's own description of the elaborate and extensive means employed for connecting the track rails, and re-enforcing them by separate wires to ensure perfect connection with one another and with the ground pipes, &c., that, aside from its danger, this plan is considerably more expensive than a second overhead wire and double trollies would be. I can only explain this action on the part of Mr. Sprague by assuming that he has found the track return necessary to enable him to ascend the steep grades of the Richmond road by reason of the increased tractive adhesion obtainable, due to the passage of the propelling current from the wheels into the rails. If my memory serves me rightly, it was not very long ago—in his address before the American Street Railway Association at their Philadelphia convention last October—that Mr. Sprague stated that on roads having grades of more than six per cent. he proposed to attach a hill horse to the motor car! Whether he intended this as a parting tribute to the usefulness of the patient and long-suffering car horse who has so faithfully served the public I do not know; but, at all events, he stated that he did not believe it possible for a self-propelled car to get up the hill in any other way. This was some time after I had announced the results of some experiments I had made, both with the electric current and electro-magnetism, in which I was able to show and demonstrate that the tractive adhesion of driving wheels could be very largely increased by these means, sufficient, in fact, to enable a motor car to ascend a grade much stepper than any yet surmounted. I may say that we are at present engaged in applying this system to an ordinary steam locomotive on a prominent railroad, and if the results obtained prove to be anywhere near what we have reason to expect from certain experiments made on a smaller scale, I shall hope to be able to show you a very decided increase in its pulling capacity, and to effect a considerable saving in the cost of operating the road.

Mr. **Pendleton** called in question the originality of some of Mr. Sprague's work, and was replied to by Mr. C. O. **Mailloux**, who instanced the case of the work done on the original steam engine by James Watt, which, however, did not debar others from the right to designate steam engines by their names when any improvement in detail involved an advance in efficiency or economy of the engine.

Mr. F. J. **Sprague**: I am rather glad that some argument has come up in the discussion of the paper. I think possibly I am in a position to correct some of the impressions which have been received so as to remove doubts about certain points. I do not care to here enter into a discussion as to whether any work that I do shall go under my name or in some other man's. So far as the difference between the Sprague motor in Richmond and the Siemens machine is concerned, either Mr. Pendleton does not know what the Sprague motor in Richmond is, or what the Siemens motor is. We use in Richmond a double commutator machine which is unknown to-day to anyone except those whom I have taught. Its plan of winding has never been published or described. It is, as I say, unknown except by the employées of my company, and if there is any question as to the similarity of that winding to some other, I have not the slightest objection to giving the necessary diagram of connections. It is a series machine, but a series machine which has some peculiar characteristics. It is wound with three sets of coils, and the peculiarity very largely consists in the method of connecting and certain switches, by which the coils in these machines are commutated and reversed, their field magnetisation and their current varied at will, through progressive changes, by means of which, when desirable, we are enabled under various loads to maintain an almost absolutely constant field, while the current may vary 300 per cent. That has never been done with a motor before; that is, to so regulate the field that, with a variation of 300 per cent., a perfectly constant field will be maintained. This field connection is somewhat peculiar, so much so that it would be useless for me to attempt to describe it now, although I shall take occasion to publish a description of it in the near future. There are, however, some characteristics of motors other than the mere winding of the armatures or fields, or their regulation, which are essential for street car purposes. It is, as Mr. Mailloux says, a question partly of proportioning, partly of calculation, a putting together of those things which you have at hand to meet those conditions under which you have got to work. Two years ago, I think I may fairly say, such a problem as equipping the Richmond Road, with its abnormal conditions, with the circumstances of manufacture which we had to meet, and in the time that was given to us in the undeveloped state of this art, would have been looked upon as somewhat preposterous. I am frank to confess that had I known what I had to go through, I would, perhaps, have had neither the necessary courage, time or patience, or have cared to have risked the money which I did. I have spent in Richmond $150,000, and I have learned something. While I do not care to state all I learned, I have taken advantage of it in our future work. A great many of the principles of regulation that have been associated with my name are not characteristic of the Richmond machines. They are designed for other purposes. Now, referring to Mr. Leonard's paper, a great many of the deficiencies he speaks of exist in Richmond, and unless the machine were of superhuman design they must exist there. A year ago those machines were put in in a great hurry. The maximum normal capacity that they ought to run at is about 7½ horse-power. Very frequently they have been called upon to develop 10 or 11 horse-power, an increase of about 50 per cent. In the nine months during which this road has been in actual operation, and it has run nearly half a million of miles and carried millions of passengers, not one working car has ever been inside of a closed shed. They have been "housed" in the street. The photograph which you have in the report of the paper read by me some months ago gives you some idea of where the cars have been kept. Of course, you are aware that when a machine is running it is exposed to more or less wear. It needs something of care and attention. A locomotive that makes two or three hundred miles is sent in to a round-house, thoroughly cleaned and taken care of. It is a very good locomotive that will run with safety, and it is very poor management that will permit it to run more than three or four hundred miles without looking it over. The Richmond machines have run sometimes as high as 6,000 or 8,000 miles without being sent inside a covered shed. They have run without covers of any kind or character. They have run with 6 inches of water in the street and brake-beams running in the water, which was splashing on the motors. They have run until you could not tell what the machine was; until the accumulation of mud and oil and filth was of such a character that no other piece of machinery in the world would ever have run. I am not responsible, unfortunately, for the management of the Richmond railway. If so, we would not have the possibility of a number of cars lying in the car shed, so-called, unfit for duty, after having been left in the streets during ten days of rain. The report from one of my own inspectors less than one week ago was that there was no more trouble in running a 40-car road by electricity than in one operating three or four cars. He is a level-headed, practical, cautious man, not given to strong statements, and very Conservative in what he says or does. He says that out of 30 cars equipped for duty, there is no difficulty whatever in maintaining 29 on the road, if only that legitimate, ordinary, reasonable care is given to the machines which ought to be given to them; and that is the opinion of others who know the exact circumstances of the Richmond management, and the character of the attendance which the machines have had. There is no electric car in the world which has ever made anything like these records—from 80 to 110 miles a day on grades as high as 10 per cent., under loads of 50 per cent. above the normal capacity of the machines in the hands of the men oftentimes appointed for political purposes and not for intelligence, on duty twenty hours a day, and making 6,000 or 8,000 miles without going inside a shed to be cleaned off. I have been called a crank, and some time ago when I made the statement, as I did in the paper that was read here, that we would get to that position in electric motors in which it would be almost an impossibility in ordinary use to break them down, and that I proposed to wash machines down occasionally, to get them clean, the remark was made, "Well, that fellow must be a damned fool." Well, I quietly pocketed that remark, and within the next 30 days or so we will have that machine out, and we will put one of those armatures that people have laughed about inside a barrel of water for 24 hours, and we will take it out and we will run it. There is no piece of electric machinery in existence to-day that will stand it. One of the difficulties which will occur on any road where the cars are not properly and decently housed some part of the 24 hours is this: Cars that are running, of course warm up, the pores open, they are ready for the absorption of any moisture. If it comes on a cold, damp, murky night, and these cars are left utterly unprotected, they will absorb more or less moisture. In dealing with the potential we are using there of 400 to 450 volts on the line, you have a possibility of a short circuit in the coils. Some of the difficulties Mr. Leonard mentions I think he might have recognised as of a purely mechanical nature, or difficulties due very largely to lack of ordinary care. The breaking of a trolley wire, sometimes caused by a trolley catching in it, can be, of course, almost entirely obviated by one or two precautions; one of these is the non-use of solder in the erection of a line. In putting up the Richmond line we used hard drawn copper. Hard drawn copper as it comes out of the mill has a remarkable tenacity, but when it has been handled, and when under the heat of a soldering iron it has been warmed up, you reduce it practically to the strength of soft drawn copper; so that you will have at the point where solder has been applied a weak spot which entirely nullifies all your other precautions. In our future work, this trouble will be entirely removed, because we will not use solder from one end of the line to the other. The use of silicon-bronze or aluminum-bronze, drawn for high conductivity and great tenacity, will likewise render less possible any accident due to the breaking of the wire. This wire can be drawn of from 100,000 to 150,000 pounds tensile strength to the square inch, and being put up without solder, I can see little possibility of that wire ever coming down.

So far as the use of poles is concerned, if you use a green pole as the poles in Richmond were, it will bend; if improperly set in a clay soil it will get out of position. If it is properly seasoned and set in concrete there is no reason why it should give trouble. One of the most important roads that we have—we have some 26 or 27 now—is the West End road of Boston. Rights for an overhead system there having been granted within a few days, we are putting up a line that costs four times as much as the Richmond line did per mile. I believe I said in my recent paper that the objection to overhead wires was entirely reasonable, because people did not put money enough into them. Having put all the money which I did in the Richmond road, I do not propose to put in any more there. On a new road, where I can make my own conditions before the contract is signed, I am willing to put in just as expensive a road as is desired. Instead of putting in wooden poles in Boston, we are putting in iron poles tested up to 1,400 pounds. Instead of setting them in clay, we set them in concrete. Those poles will not come down. So far as the span wires are concerned there is no danger of their breaking.

As to the use of a single overhead line, that, I know, is a much discussed question. But I find the practice of most people is a single overhead line. There has been a good deal of kicking on the part of telephone companies. It has chiefly disappeared down in Richmond. The trouble is that the telephone companies had the earth and they wanted to keep it. I can see no particular reason why a telephone company should not be required to exercise the same degree of care in putting up their lines that they would if the electric railroad were already in existence. The telephone man runs out his circuit as far as he can and charges as much as he can, and then, because some poor railroad company wants to put in some cheap and effective system for operating its cars, I do not think that it is quite just on the part of the telephone companies that they should raise their hands in such holy horror over the use of the earth circuits. Mr. McCluer, of Richmond, who was mentioned, had ingenuity enough to get out of his troubles. He took the trouble to run over his main telephone circuit, where they came near our wires, a single return wire, and he makes his telephone connections to that. His troubles have disappeared. I suppose it might have cost his system a few hundred dollars. If he objected to paying that, I suppose we could have paid it for him, but he has, as I say, overcome his troubles by the most trivial possible expense. If that is the only objection that telephone companies have got, it is not a legitimate objection. So far as the burning out of their exchange is concerned, I will have to correct Mr. Leonard in that. At the time one of their decayed poles fell down and landed three or four hundred wires on top of our lines, the dynamos were not running at all. This is the only pole breakage I know of. We have burned out some of their instruments, but that is simply because we took a reasonable amount of precaution, and they did not. They got their wires across ours, and they got the worst of it. The great trouble with telegraph and telephone business is this—the thousands of miles of dead wires hanging down in the streets and over the house tops. A man who has a telephone does not take the trouble to take down his telephone wire after he has discontinued the service. There is no æsthetic sentiment in a telephone company. They are perfectly willing to say: "Here, you electric light people and you electric railway people are causing a great deal of trouble to our customers." If they would all join hands in an equitable arrangement, as some of them have, they would have little cause to complain.

A criticism has been made about the use of two machines on a car. I have spent half an hour trying to get the length of this room with one motor on a 6 per cent. grade, under a condition which happened to give a slimy surface on the rail, and I have seen under the same conditions, on a 10 per cent. grade, on a worse track, two motors handle the heaviest loads. It is not merely because the wheels can get a better grip—you have got you total weight available for traction. The forward wheels can also in case of an emergency travel faster than the rear wheels. That has been done—even on a level, and has the advantage of breaking up whatever obstructions there are on the track and leaving the track perfectly clear; if you put between your wheel a broom or brush you have excellent traction. It could not be done by gearing both wheels to the same motor, simply because you could not get that independence of grip that is necessary. Running both pairs of axles requires certain devices, the use of which, in view of existing street car practice in the matter of constructing running gear, I do not think is advisable. There are some 40,000 or 50,000 cars in the United States, and there are one or two settled principles in them; one is, perfectly independent action of the axles. No four wheels on a car are of the same diameter; they are never cast absolutely alike; they do not run necessarily on the same tread. Any difference in the level of the streets will send the weight of a car down on one side. In fact, it seems to me, in the face of all I have seen, almost trivial to make any objection to the independent driving of two axles. I admit it is cheaper to build one machine to put on a car, but you can build two smaller machines of the same capacity. Space in a street car is a matter of considerable importance. You want to get large power on a car to handle heavy loads, but you have got to have it in comparatively small space.

As to keeping a trolley on a wire, I am quite willing to enter into a contract to put a trolley on a car which never can come off the wire, and, in fact, some of our cars are now running with one man, and have to run with one man, simply because the railroad people won't pay an additional conductor.

The methods of getting rid of troubles have been, of course, subjects of a great deal of study. It was not possible a couple of years ago to look forward and face all the conditions that arise in practice. We electricians did not know enough about street car practice, and street car men did not know enough about electric railways, so we had to join hands with the street car men, and we had to put the cars and motors into the hands of ignorant men and meet those difficulties in order to know how to get over them. I think I may safely say that the road we put in 60 days from now will bear about as little resemblance in details to the Richmond road as it is possible for any two roads to bear to each other, simply because of great improvements, not only in the motors, but in the gearing, switches, trolley work, and all overhead superstructure.

A two-wire system requires from two to four times the weight overhead. Where we put a main conductor alongside of the street and reduce the trolley wire to a single one, a fifth of an inch in diameter, that enables us to keep our structure in position a great deal better. So far as safety is concerned the fact that a horse was killed in Richmond in the early days of running is no criterion of it. Two wires are more liable to come down than one; but you won't get killed with 400 or 500 volts. I have several times taken that potential myself. We don't know whether the horse that was killed in Richmond broke his neck or was killed by electricity. He was boiled in order to get his skeleton; he did have a broken neck; it is not known whether that killed him. We had a mule there. A man threw a lump of ice down on to our wires. The first mule—two of them were being driven by a darkey—ran his head into the wire, and kicked, and finally fell down and lay on the wire. About half an hour after that they telephoned up to the general manager's office, and said, "We have got a mule pretty well used up by a current; we want damages." He said, "All right." About 48 hours afterwards they sent up word that they did not think they wanted any damages; that mule seemed to be a great deal livelier than before. In the case of the horse that was gross carelessness on the part of everybody concerned—the conductor who broke the wire, the dog who investigated it, and the boy who rode the horse; but the only one injured was the horse.

The statement that the Richmond Company has never been able to run more than 30 cars out of 40 is an error. The Richmond road never expected to run more than 30 cars out of 40. Its plant was built for 30 cars. A 40-car motor equipment had nothing to do with their line work, or their central station work. It is perfectly possible, as a matter of fact, to run the entire 40 cars.

As far as the use of the storage battery is concerned, I am just as anxious as anybody else that the storage battery should be a success. But it will never get on a car in Richmond when they have got to put 4,000 pounds weight on that car. They never will take 20,000 pounds weight up a 10 per cent. grade with a storage battery until it is in a good deal higher state of efficiency than it is to-day. We have, although not prominently connected with storage battery work, been experimenting for a long time. We keep a car on tap. We have had built hundreds of plates in the past year, trying to devise some means of overcoming the difficulties that exist in storage batteries now. We hope to have a normal capacity of discharge in, say, a 35-pound cell of not less than 75 or 80 ampères, and that they can stand 150. The resistance ought to be about one-third or one-fourth of the present storage battery. The plates will be practically indestructible; and, finally, it won't be a Faure cell. That is the sort of thing I am looking for. I do not know whether we will get it. The results, so far, have been very encouraging, but we never will attempt to climb a 10 per cent. grade with it, and we never will put it on the market until we know it is satisfactory. We will do our own experimental work. We expect to get the battery down so that not more than 1,800 pounds is necessary to handle the car under ordinary conditions. That will be something of an advance. The credit will not be mine, except that I have to pay the bills. Two years ago it was not possible to design a street car motor for entirely perfect work. I do not think enough was known about street car work. Certainly we are in a position to-day to design a great deal better machines than we did then. I shall have the pleasure of showing and explaining to this association in the near future our two latest machines—one about 7½ horse-power, the other about 15—and their construction, I think, will appeal to street car people at least. I think by the time the Boston road is running, which will be in about five or six weeks, if Providence is not against us in the matter of the weather, we shall be able to show such improvement in the overhead line, as to its efficiency, economy and appearance, the character of the motors and the work which they will do, as will be a subject for mutual congratulation.

Mr. L. F. Lyne: I would like to ask Mr. Sprague if he really meant that a locomotive only runs 150 miles before it needs repairs. I think he meant 1,000. There are reporters here, of course, and if they get that wrong it will not sound well. I understood Mr. Sprague to say 150 to 200 miles.

Mr. Sprague: I might as well correct that impression at once, if you will permit me. I said it was not practicable in locomotive work to run over 200 to 400 miles without the locomotive going under shelter and being properly oiled and cleaned; I did not mean going into the repair shop. What I said about the Richmond machines is this: They are not put inside of four walls; they are simply left in the streets. You cannot leave a locomotive or any other machine in the streets for eight months under all conditions of the weather and have a machine that will not be apt to sometimes give you trouble. I was quoted a little while ago as making a remark about hill horses. I was asked by a man who was interested in storage batteries—I believe he lived in New Jersey—if I would recommend in the equipment of a road which ordinarily did not have more than two or three per cent. grade, but which did have in some particular places a heavy grade of eight or nine per cent., the use of motors which would climb a nine per cent. grade? I said that as a matter of commercial investment I would say no. I said: "You will find it cheaper if, when you get to that eight or nine per cent. grade, you take the trouble to put on a horse." That, certainly, was the intention of my remark. So far as Richmond is concerned, I did not expect in the first place, that we were going to have a ten per cent. grade there. Our specifications are for eight per cent. We have in some places the equivalent of a thirteen per cent. grade. We develop a remarkable traction, a traction which I never anticipated would be gotten out of a car; but no matter how we magnetised our wheels there, unless we drove both axles we never would get up these grades at all times.

Mr. Lyne: There are one or two remarks made by Mr. Leonard that I would like to refer to. The devices, so far as I have been able to discover, in transmitting the power from the motor to the shaft of the car or axle of the car, have been in many cases obsolete devices. For instance, the grooved friction wheel has been used on the "Ben Franklin" that was tried on the Ninth Avenue road. That device was condemned by engineers years ago, because the friction wheel caused flat places. If a sufficient pressure was not brought to bear on these wheels to bring it up to the maximum point at once, the surfaces would slip on one another, and the grooves would have a flat place. When the Fontaine locomotive came out we were led to believe that the whole railroad system of the country would be revolutionised in a few months by that engine. A certain few predicted its utter failure, and it failed, principally in consequence of the tires getting flat places on them. As soon as they did get a flat place they began pounding themselves to pieces, and the result was a dismantling of the whole affair. We know that the same occurs in locomotives in climbing grades. They slip, get flat places, and then the wheels have to be turned off, or the tires, rather.

Mr. Sprague: The question of depreciation of line is a question of construction very largely. It is certainly not a question of wear. A consideration of the actual time in which a wire is in contact will show this. With cars that are running seven miles an hour, with a round trolley wheel, making contact on a round wire, we have almost a line contact, but call it an eighth of an inch contact. Any portion of the wire is in actual contact with the wheel less than $\frac{1}{2000000}$th part of the time; in other words, in continuous current contact, not over one hour in twenty-six years. Consequently the current ought not to rapidly wear the wire out, and it does not. In fact, the period in which any particular part of the wire is in contact is not over $\frac{1}{2000}$ths part of a second when the car is moving 7 miles per hour. The question of insulation, leakage and lightning came up a little while ago. It is a remarkable fact that lightning does not necessarily follow always the single overhead wire. We have had in Richmond quite a number of cases of the line being struck by lightning. Our ground circuit is made by three paths: two through the boilers and water connections, and a third through by a covered wire running about 1,000 feet on poles out, and directly down, to the track. We have had lightning come over that wire several times, and the statement of the engineers is that it is about an even thing whether it comes in on that line or the other one. It terminates in a well, and as a matter of scientific interest the engineers sometimes watch it as it goes into this well. So far as the leakage is concerned on that line it can easily be reduced to an average of one-tenth or one one-hundredth part of one per cent. It has never been sufficient to cause the slightest interference with the operation of the wire except in the case of the short circuit. If existing, it can very easily be perceived by taking the reading of the ampère meter. The leakage is nothing so far as loss of power is concerned.

Mr. D. E. Lain: About the only part of the matter that I wish to speak of now is the means of coupling the motor to the axle. In Mr. Sprague's excellent paper he compares the method of direct coupling with the others, coupling by means of chain gear, friction gear, &c., in a way which, I think, was rather hard on the direct coupling. I have had some experience with some of these ways, and it seems to me that the method of direct coupling offers certain advantages which no other method offers. The easy motion and perfect noiselessness of the coupling certainly place it ahead of any other means. The simplicity, of course, in this method, is greater than in any other. All the details are reduced to a minimum. The objection, of course, is that on account of the slow speed at which the armature must necessarily run—running no faster than the driving wheel—a larger machine is necessary. This may be an objection, and may not. In street railway work, where certainly not more than 10 horse-power is required, where the whole equipment should not weigh more than, say, 5,000 lbs. when the car is loaded, the weight of the motor enters as a part of the whole weight; with the weight of a direct coupled motor, that is not of such great importance after all. If the drivers be reduced to, say, 18 inches, or thereabouts, a motor can be built that is not necessarily over 25 per cent. greater in weight than one using gearing. This small difference is due, in part, at any rate, to the greater efficiency of direct coupling over the gear. Of course, gear transmission is not possible where speed is reduced or changed from, say, one to twelve or one to ten without some considerable loss of power. All this is saved in the direct connection where the loss by transmission should not be more than a very few per cent. I think before the close of a year, at least before the close of next year, results will be obtained with direct coupling that will show it is possible to use a direct coupled motor even for such small work as street car work, that is quite as efficient, taking it all the way through, and taking the total efficiency of the system, as gearing.

Mr. M. B. Leonard: With reference to the statement in my paper regarding the burning out of the telephone exchange, that statement was based on information I received from the telephone manager's office yesterday afternoon. In regard to the difficulty and trouble experienced by the telephone exchange people on account of the ground circuit of the electric railway, it has been largely, if not altogether, remedied, by the erection of a metallic circuit, or what amounts to the same thing, namely, running along a large copper wire to which the telephone wires are grounded, instead of going to a gas pipe, as they ordinarily do. The difficulty has been obviated in that way, but there are quite a number of private telephone lines put up by various people, including our railroad company, who cannot afford to go to the expense of putting up metallic circuits, and the result has been that we have been obliged to discard our private telephone line and pay tribute to the telephone company and their metallic circuit system. With reference to the mechanical difficulties which Mr. Sprague alludes to, and which of course have been improved upon since the road was first erected, it is true that those mechanical difficulties can be considered as such by observation; but the electric road at Richmond was put forward as being a sample, I may say, of what has been accomplished, and of course we could only take what was actually being done and criticise it accordingly. This I endevoured to do in the few remarks I made. That the work is susceptible of improvement is, of course, at once apparent to almost everyone.

Mr. T. W. Rae: There is nothing that I have to say in addition to the remarks that have been given to-night, but I would like to record my hearty concurrence with Mr. Sprague's dictum respecting overhead lines. It is simply, as with most engineering questions, a financial rather than a technical one. One may have a good, durable, sightly overhead line by simply paying sufficient money for it. As at present constructed they do develop obstacles of various kinds, and certainly are not as symmetrical as they might be, and do lack the perfection that might be given by the expenditure of more money. This question arises though: It is quite possible, I think, to make use of an underground conduit at perhaps no greater expense (certainly no greater, when one considers the cost of maintenance of a properly built conduit) than a properly built overhead system would entail, and the difficulties which Mr. Leonard referred to, I think, cannot fail to be recognised by everybody; but that they are essentially inherent to the system does not necessarily follow, as Mr. Sprague has pointed out very clearly. The question is a financial one rather than a technical one.

Mr. Sprague: I think we will know much more about it when we have gone through a Northern winter, which we shall do very soon. We have cleaning cars, and we shall put ample power behind them, and can do the work much faster than with horses, because we have the power behind rather than ahead of us.

Dr. S. S. Wheeler: Mr. Sprague, in speaking of the liability of the wire to wear from the electricity, mentioned the fact that it could not possibly wear because it was only in contact at one point a very small part of the time—about a thousandth of the whole time. I should think that the fact of wear would be due to a very minute jump that the current would have to make when the roller hops a little bit off the wire. In fact, when he said that the roller was only in contact with any particular part of the wire about a thousandth of the time, I thought he only referred to the danger of it hopping off.

Mr. Sprague: It was not that to which I referred. It is not the same as a sliding contact on the wire. Your wheel is turning all the while, and there is no difference of potential between the part you leave and the part you are going on. You have a good contact where the trolley is held up by a good spring; you may inspect that wire by a microscope and detect very little signs of wear at all. There would be a very slight frictional wear, and it is probable there is a certain percentage of slip of these trolley wheels on the wire. I have, after eight months wear on the very heaviest portion of the line, very carefully inspected the wire, which was chemicaliy cleaned, and I was agreeably surprised to see the small evidence of depreciation. If there is no sparking then the wear is entirely due to friction. The fact is the wear is remarkably light. I would like to make one remark in regard to lightning. We had the line struck by lightning several times, and we have had motors on cars burnt out, but I believe I may safely say now that we have got lightning pretty well harnessed. I believe now there is no difficulty whatsoever in absolutely and perfectly guarding a car or a central station, so that lightning simply cannot get to the machine. We have had the lightning come in and ground through the switch at the time the motor men were running the car. They paid not the slightest attention to it. They simply heard the click—that was the end of it. It will now be perfectly guarded against. It cannot get into our machines, and it cannot get into our stations; at least if it does it is only one time in 10,000, and then it goes to earth harmlessly.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1887.

12418. "Improvements in conveying electric energy and in applying the same to the production of motive power." S. Z. de Ferranti. Dated September 13. 11d. The inventor uses alternating currents of high intensity, preferably derived from an electro dynamo-electric machine, and to convey these currents to the places where they are to be utilised, he employs a conductor or cable which he suspends from supporting wires carried upon posts. He utilises the alternate currents for obtaining motive power, by causing them to pass through a compound apparatus consisting of two electro-motors. The principal motor is one without commutator and such that, when running at a suitable speed, it will maintain this speed and synchronise itself with the alternation of the currents passing through it. The other electromotor is of much smaller dimensions, it is provided with a commutator and is capable of starting from rest when the current is passed through it. The armature of this machine is geared with or preferably on the same shaft with the armature of the first electro-motor, so that when the circuit is first closed the small motor drives the armature of the main motor, and so brings it to the speed requisite to enable it to work synchronously with the current supplied to it by the circuit. The claims are 11 in number.

12419. "Improvements in electric railways." S. Z. de Ferranti. Dated September 13. 11d. At a main station upon the line a dynamo-electric machine is provided generating alternating currents of very high tension. These currents are conveyed along the line for a long distance by a conductor, preferably suspended upon posts. The line of rail which this conductor serves is divided into comparatively short sections, say each of a mile long, and for each of these sections another insulated conductor is provided in which a comparatively low working tension is maintained. A train passing on to any section of the line closes the circuit of this low tension conductor through the electromotor or motors which the train carries, and the train is propelled. The tension in the sectional conductor, which serves to supply the motors on the trains is maintained by means of converters or induction coils. The high tension current is allowed to pass in the primary fine winding of the converter and it develops tension in the secondary or thick winding which is connected with the sectional conductor supplying the train motors. For each sectional conductor two converters are provided, one, a small one, is intended to maintain the tension whilst no train is upon the line; the other, the large converter, is intended to supply the current for propelling the train. Through the small converter the high tension circuit is constantly closed, but the high tension circuit is only closed through the larger converter when a train is upon the line. Thus a waste of energy which would occur if the main converter were constantly excited is avoided. The closing of the main circuit is effected automatically by means of an electro-magnet or its equivalent in the low tension circuit of the smaller converter. When in consequence of a train passing on to the line this circuit is closed, a powerful current immediately passes; this current excites the electro-magnet, which operates a switch which closes both the circuits of the main converter. The claims are 7 in number.

12437a. "Electrical measuring instruments." R. E. B. Crompton and J. Swinburne. Dated September 14. 8d. A hard steel needle is placed inside a coil as in a vertical detector. As the current increases the needle is deflected. To increase the angle of deflection the needle is balanced so as not to stand at right angles to the axis of the coil. By balancing the needle so as to make different angles when there is no current, we obtain a scale of any desired character; that is, we can make an instrument that will read well throughout its whole scale. The needle should be magnetised so as not to weaken with age. For ship use and other purposes the magnet needle may be controlled by a spring instead of by the action of gravity. The claims are 3 in number.

12830. "An improved regulating device for use in electric arc lamps and for other purposes." W. R. Lake. (Communicated from abroad by O. H. L. Lindemann, of Hamburg.) Dated September 21. 8d. The object of this invention is to equalise the irregularity in the attraction of the solenoid acting upon its core, which has heretofore been effected by means of the so-called Krizik and Piette's solenoid cores, varying in quantity in the direction of its length in inverse proportion to the attraction of the solenoid, and it comprises the employment of a considerable number of solenoids, arranged co-axially to one another in combination, with but one conjoint core of equal quantity throughout in the direction of its length. The claims are 2 in number.

12880. "Improved method of producing solid metal sheets by electro-deposition, suitable for compass cards, stencils, and open-worked flat or curved articles for decorative and other uses." W. J. Reynolds. Dated September 22. 6d. The object of this invention is to make articles solid in themselves, but of flat or curved shape, with interstices or openings to form patterns or designs; to render such metal articles suitable for ships' compasses in place of, or in conjunction with, the present forms of cards, transparent and other, or for mounts or surface pieces, inlaid or not—for decorative and other uses—for stencils and general purposes for which they can be available. The articles being produced through a novel method or process by electro-deposition. The inventor takes a circular sheet of highly polished plate glass and paint the representation of a compass card, or the reverse of one, on one of the surfaces, and when the paint is dry he makes a raised edge in putty or cement round the glass to form a kind of well, or basin, into which fluoric acid can be poured to the desired depth. This acid eats into that part of the glass which is not painted. When the glass is sufficiently bitten away he washes the acid off and removes the cement edging, and makes the glass clean by removing the paint by the aid of turps or other agent. He then takes a piece of marble or of glass and rubs the surface of the partly prepared sheet of glass, using emery powder and water for roughening the raised or unbitten parts of the glass surface, namely, that part from which the paint had been removed. A coating of black lead or its equivalent is then put upon the glass, the particles adhering to the roughened portion only, said black lead or carbonaceous body acting as an electrode when the glass is suspended in a bath of sulphate of copper, the other pole being in a porous pot also within the path and in electric contact. The length of time the plate is left in the bath is determined by the desired thickness of the deposition which takes place in a well known manner, so that the plate of glass when removed has affixed to its surface a metal body, but only at the parts which had been previously coated with the carbon. The result is, an article, in solid metal, with interstices or spaces, between the division points or indications of the compass, in bold relief, with sharp well formed edges, the article being ready for mounting as a card or dial. The claims are 2 in number.

12924. "Improvements in the manufacture of incandescent electric lamps and of carbon rods therefor." G. Zanni. Dated September 23. 8d. The inventor uses hollow carbon rods which are made from paper or other material by rolling the said material upon a mandrel, or forming it into hollow rods in any other convenient manner, and then carbonising the hollow rods thus formed. Or he can use rods consisting of straw or other natural products treated, for example, as described in specification, No. 2,741, June 10th, 1882. The claims are 4 in number.

13154. "The application of electricity to the controlling of gas and and other cocks and valves." H. R. Fisher. Dated September 28. 8d. The inventor provides a recess flanged cap of novel construction, preferably circular, which fits, and is secured in any suitable manner to the square shoulder of the plug of the cock, tap or valve to which the device is to be adapted. Upon said cap, which has a square or other shaped projection to allow of the same key being used thereon that was originally made for the cock, is loosely fitted a lever having two arms of different lengths, to the shorter one of which is attached a weight, the position of which latter upon the arm is adjusted by means of a set screw or equivalent. Upon the longer of the aforesaid arms is suspended a slotted rod, to the lower extremity of which is fixed a tray or carrier for holding weights. Within the upper part of the slot is fitted a small pulley, which, resting upon the upper edge of the lever above mentioned, allows the carrier and weights to move freely from one end to the other thereof. The extremity of the long arm of the lever is hooked, and embraces a pin attached to the armature of an electromagnet. When the electromagnet is at rest, the pin aforesaid maintains the lever in a horizontal position, and the gas or water is allowed to enter the building, but as soon as the electric circuit is closed by means of a contact, the armature being then attracted to the electromagnet, releases the pin from the lever, which latter falls, allowing the weights to ride to the extremity thereof; the downward pull increasing with the increasing distance of the weights from the centre. The claims are 4 in number.

13561. "Improvements in electricity meters." H. W. Kolle. Dated October 6. 6d. Relates to that class of electricity meters employed in the measurement of alternating currents. The inventor has discovered that in a suitable electrolytic cell an alternating current can be used to precipitate metal from one or both of the electrodes, or to cause a chemical union to take place between one or both of the electrodes and the electrolyte. For this purpose he takes two masses of lead, copper, or any other suitable metal, and places them in any suitable electrolyte, acid or alkaline, such as dilute sulphuric acid or caustic potash, and on passing an alternating electric current through a cell so formed, the electrodes lose in weight. This loss, being proportional to the current passed through the cell, serves as a measure of the same, and the amount of loss of the electrodes can be ascertained in any convenient manner. The claims are 4 in number.

14529. "Improvements in microphones." C. Bell. (A communication from abroad by L. M. Ericsson, of Stockholm. Dated October 25. 8d. Claims:—1. The construction, or arrangement and combination of the parts of microphones, substantially as described in reference to and shown in the drawings. 2. The construction and use of a microphone, in which the one contact is a carbon bar fixed at a point placed in the centre of a diaphragm, and the other contact is composed of two or more round carbon bars fixed in the upper ends of metal cylinders, which are placed sloping, or at an angle, with their bottom ends resting upon metal pins, so that they can easily revolve, all substantially as described in reference to and shown in the drawings.

1888.

713. "Improvements in voltaic or galvanic batteries." T. Coad. Dated January 17. 8d. The inventor uses porous pots with a suitable portion glazed, or otherwise treated to prevent percolation and endosmose and exosmose when not in action, the carbon plates or electrodes are permanently sealed into the porous pots, leaving an orifice for charging and discharging, which can be securely stoppered; the carbon electrodes are preferably fitted with metallic contact pieces. He seals or otherwise fixes in the partitions of the cells or compartment which contain the exciting solution—porous pots and zinc electrodes, pieces of suitable material, "preferably" platinum, the carbon electrode being on one side of said partition and the zinc on the opposite side; the carbon and zinc electrodes are connected and kept in contact with the pieces of metal fixed in the partitions by inserting wedges of suitable shape and material between the porous pots and zinc electrodes, thus enabling them to be removed without disturbing the connections, and it also prevents the exciting fluid from flowing into the adjoining cells or compartments when the battery is reversed. The top of battery box is provided with a ledge on which rests a piece of suitable material such as India-rubber, and kept in position by a suitable cover secured by bolts and nuts. The claims are 3 in number.

5681. "Improvements in switches used for electrical purposes." C. S. Snell. Dated April 17. 8d. In one form the end of the switch or contact arm is notched or stepped, so that a series of horizontal surfaces or faces is formed thereon, and the contact blocks or pieces are similarly notched or stepped to engage or interlock with the arm, and further to admit of a certain amount of flexibility for adjustment a series of saw-cuts or divisions, preferably horizontal, are made in the contact arm or in the contact pieces, or in both. To regulate the pressure between the surfaces in contact adjustment is made by means of screws or bolts near to and in such manner as to admit of expanding or contracting these interlocking parts as may be desired. The claims are 5 in number.

7619. "Primary electric battery." G. J. Weir. Dated May 24. 8d. Consists in grouping a number of carbon rods closely about the zinc. In one form of cell the rods may be separated from the zinc and from each other by Indiarubber, or other suitable material, and may be kept in position round the zinc by elastic bands. The ends of the carbon rods may be coated with copper, to which a copper ligament and other wires may be soldered. The claims are 2 in number.

CORRESPONDENCE.

Leclanche and Gassner Batteries.

In reference to the remarks in your issue of November 2nd, upon my short paper read at the recent British Association meeting, I have to say that the object I had in view was, not to compare the two cells under the most favourable conditions possible, each one being newly set up with a view to give its maximum result, but to compare cells which might be considered fair *average* specimens of each, after they had been a short time at work. The Gassner cells were not new, but had done much intermittent work on bell circuits, &c., for seven or eight weeks. The No. 2 Leclanché cells employed had also been set up here for a similar period, and had been occasionally, but not frequently, employed on testing circuits, &c.

I may add that M. Barbier is in error in saying that the cells were circuited through an "interrupted circuit" of 20 ohms resistance; the circuit was continuous, and its amount was decided by the fact (as a reference to the original paper will show) that the resistance of a ringing bell, determined by the reproduced deflection method, was found to be equivalent to 20 ohms.

Wm. Lant Carpenter.

November 7th, 1888.

The Phonograph and Graphophone.

The communication signed "K," in your issue for the 19th inst, on the above subject, seems to call for some reply on my part.

Your anonymous correspondent should be aware that it is often easy to reproduce single sentences from an article, which taken alone, and without the context, convey a very different impression from that given by the article as a whole.

I have re-read your article of the 5th inst., and, notwithstanding the two sentences quoted by "K"—sentences which certainly did not escape my observation when I first read the article, but which induced me to qualify the remark to which your correspondent takes particular exception by the words "to some extent"—the general tenor still gives me the impression that you were desirous—with the best intentions I am sure—of minimising the probable importance and usefulness of the instruments in question, and it was merely to raise some small protest against this that I troubled you with my letter.

With regard to your correspondent's further remarks, it is difficult to see how there can be any comparison between criticisms on the Water battery and the phonograph, for whatever the useful future of the latter, it is, at all events, a *bonâ fide* invention of real merit.

As to the instance I gave of an invention lying dormant for years before its practical merits were acknowledged. Your correspondent apparently entirely forgets that telephones were made as early as in 1862 by Philipp Reis, so that taking his own figures as to when the telephone came into practical use, your correspondent must admit that it had then been in the scientific toy stage for no less than 15 years. No doubt Reis's telephones were very imperfect, but that they could and did transmit articulate speech is now admitted by every unprejudiced person. In any case, Reis's instruments were in their way quite as efficient as Edison's original phonograph, and the improvements that have recently been made in the latter may be very fairly compared to those made by Bell and Hughes on the former.

It is true that Edison sometimes employed flat discs for his early phonographic records, but he seems invariably to have used a metallic foil surface, though in one case he suggests mounting this on a soft waxy support to admit of its being easily indented. There does not seem to be any record of his having successfully used hard wax alone, and there is no mention in his several patent specifications of anything similar to the cutting style used in the graphophone.

The reason why the cylindrical form of record is still retained is, doubtless, merely because of its being more convenient than the disc from a mechanical point of view, cylinders being less apt to get out of truth and being more easily turned up true in the first instance, but there can be no question that for convenience in storage and transmission by post, the disc form is much the best, and I notice that the latest of the published graphophone patent specifications is entirely devoted to a disc machine, which is therein stated to posess many important advantages.

The existing postal and telegraph monopoly is, perhaps, the only one in this country that has not prejudicial effects that more than counterbalance the good, and for an instance of the paralysing effect of a monopoly, without, perhaps, a single redeeming point, one has only to look at the present state of the telephone in England generally, and especially in London.

As it is probably precisely in the points of style and size that we must look for improvements in the phonograph, it seems doubtful whether instruments with interchangeable records are for the present practicable.

It does not appear to me that much good can result in carrying this controversy further, but I may state that I have personal knowledge of more than one firm who are only waiting for the phonograph to be put on the market to commence using it for ordinary correspondence at once, and doubtless the number of such would be immediately increased were improvements in the direction I have indicated successfully introduced.

A. A. Campbell Swinton.

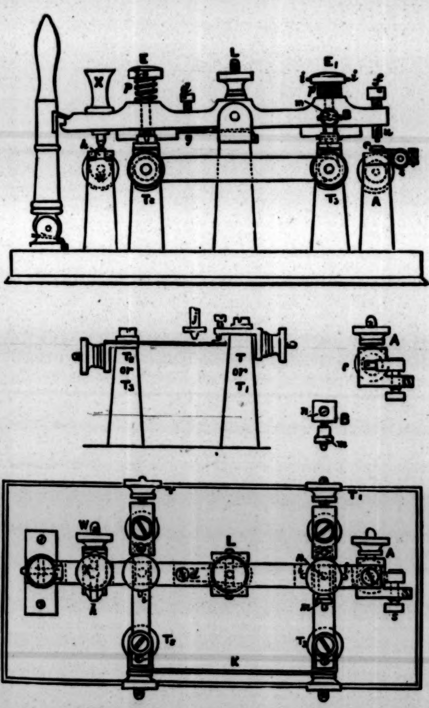
October 31*st*, 1888.

Testing by the "False Zero" Method.

It having come to my notice that many operators find great difficulty in performing the manipulations necessary for obtaining good results with the "false zero" method of testing, I am tempted to ask you to kindly publish in your valuable paper the accompanying sketch and explanation of a key devised for the purpose of facilitating the operations, which the method alluded to necessarily involves.

Although the aim I had in view in constructing the key was that already mentioned, it will be seen that the device, which is in reality a combination of a "discharge key" and "galvanometer short circuit key," can be used also for charge or discharge, per cent. of loss, direct deflection, or ordinary conductor resistance tests. Unless the key is being used for a "false zero" test (in which it is always an advantage, at least when testing to a fault or break, to use zinc to line only, and so avoid all possibility of reversing the current), a battery reverser should be used with the key.

For the benefit of those amateurs who have not a clear idea of the meaning which attaches to the words "balancing to false zero," I would explain that the position which the spot of light assumes on the scale, when the cable current only is flowing through the galvanometer, is called the "false zero" (I consider that cable current or earth current would be a less incongruous mode of expression), and that in a Wheatstone bridge test, when on application of the battery the spot comes to rest at this "false zero," we have balanced to it, and have obtained a practically correct measurement of the resistance between the home end of the cable and the earth.



It will be seen that the key is so arranged that the galvanometer can be kept closed until after the first rush of battery current into the cable, and that after the battery has been disconnected from the cable the galvanometer can be kept closed for any convenient time, to allow the discharge to pass to earth before the cable current is observed.

The way in which the key works is as follows:—The spring contact, E, at the front end of the key, to make and break the galvanometer circuit, can be used as a "tapper," or can be permanently held down to keep the galvanometer circuit open by turning it round when at its lowest limit; the ivory pins, *i*, *i*, enabling the operator to feel exactly whether the button, E, is in a position to rise or be held down. At E_1 the construction in this respect is the same, only there is the additional provision to keep *j* fixed in any position required between its highest and lowest limit by means of the slide, B, which clutches the rod, *j*, passing through it at N, and enables it to be clamped by the screw, M. When M is unscrewed the button again rises under the influence of its spring, *p'*.

In every case the contacts have been made adjustable, the adjustment at A being very considerable, by turning the screw which raises or lowers it.

By means of the screws contact can be made between *u* and *c* before *j* breaks the galvanometer circuit; or the reverse action may be obtained by adjustment.

The following are the methods of joining up for the various tests:—

Bridge Test.—Centre of bridge to L; galvanometer between T and T_1; one pole of battery to W; A to earth through resistance equal to that of battery.

To observe any earth current, or current from a fault, when the lever is released, contact may be first made at *u* and *c*, and the galvanometer circuit afterwards broken by depressing E_1 at will, either by hand, or the position of *j* may be so adjusted by means of clamp B to bring this about automatically; the duration of the contact at *u*, *c*, before *j* automatically breaks the galvanometer circuit, being capable of considerable adjustment.

This last method of working is one of the special objects of the key. T_2 and T_3 are for every test joined together by a brass strap, K.

Capacity, or Loss per Cent. Test.—Cable to L; A to T_1; galvanometer between T and T_1; T to earth, and W to battery.

On depressing the key the cable is charged direct and discharged through galvanometer when key is released. For loss per cent. during one minute's insulation the lever is held midway between the front and back contacts, *h* and *c*, by the trigger in front.

Insulation Test.—L to T_1; A to earth; galvanometer between T and T_1; T to cable, and W to battery.

The buttons, E and E_1, enable the galvanometer circuit to be opened when required during the earth readings, as well as during the insulation readings.

I take this opportunity of reminding the readers of this article that in testing for the distance of a fault care must be taken to so arrange matters as to have throughout the test as nearly as possible the same current flowing through fault (unless the distant end be left free and the total resistance of cable and fault be obtained with different E.M. forces, the fault being then localised by applying Kennelly's law). This may be done by adopting Kennelly's overlap method (page 581, vol. xvi. *Society Telegraph Engineers and Electricians Journal*), or when it is determined to test from one end only by employing the method described on pages 534—536, vol. xiv., *Society Telegraph Engineers and Electricians Journal*. In this latter method where a Wheatstone bridge is employed the *modus operandi* is as follows:—

First by taking a simple "Blavier" test, approximate to distance of fault, and let that approximation from testing station = x in ohms; from that obtain approximate resistance from the fault to the distant end—y ohms—and approximate resistance of fault—z ohms. With these data we next obtain an approximation to the resistance which must be inserted in the main circuit of the battery when testing cable with its distant end free.

When an even bridge is used—

Let a = E.M.F. of battery,
„ r = resistance of battery,
„ r'' = „ on either side of bridge,
„ R, R_a, R_b, &c., = resistance employed when equilibrium is obtained with distant end free,
„ R', R'_a, R'_{1b}, &c., = resistance employed when equilibrium is obtained with distant end to earth.

R_1, R_2, R_3, &c. = first, second, third, &c., approximations in ohms to resistance which must be inserted in main circuit of battery when testing line free at distant end.

When distant end is free

$$\tfrac{1}{2}\,\frac{a}{r + \dfrac{r'' + R}{2}} = \frac{a}{f} = \text{current through fault.}$$

When distant end is to earth

$$\tfrac{1}{2} \cdot \frac{a}{r + \dfrac{r'' + R'}{2}} = \frac{a}{g} = \text{current through } x.$$

Portion of $\frac{a}{g}$ flowing through fault

$$= \text{roughly } \frac{\dfrac{a\,y}{g}}{y + z} = \frac{a}{h} \qquad \text{then}$$

$\frac{h - f}{2}$ will represent the first approximation for resistance to insert in ohms, or R_1,

$$\frac{a}{f'} \text{ will then} = \tfrac{1}{2} \cdot \frac{a}{r + R_1 + \dfrac{r'' + R_a}{2}}$$

$$\text{and } \frac{a}{g_1} \text{ will then} = \tfrac{1}{2} \cdot \frac{a}{r + \dfrac{r'' + R'_a}{2}}$$

and so on until $R\,n = R\,n - 1$ = correct insertion.

H. Kingsford.

An Electricity Meter.

From the report of Mr. Lowrie's paper "On the measurement of electricity in a house-to-house supply," read before Section G, British Association, and published in your issue for September 21st, I gather that Messrs. Lowrie & Co. claim that by superimposing the current from an accumulator cell on the alternating current, delivered direct or through a converter to the consumer's circuit, and placing in said circuit a copper or other voltameter, they thus obtain a combination of elements constituting the most reliable and accurate system of meterage yet devised—one which, under favourable conditions, must be absolute in its indications, and under ordinary conditions must give an accuracy of at least 98 per cent.

Now, when one considers the nature of the elements entering into this combination, also the hard and variable conditions "ordinary" to a meter, and through which, before we can call it good, it must preserve its accuracy, the claim, practically for perfection, made on behalf of this meter by its inventors, seems unreasonable. Methinks if an American electrician made such a claim for a similar system, it would aptly be set down as an instance of what it is some folks pleasure to call "Yankee audacity."

When it is required to obtain from the electro-deposition of copper results that shall not greatly vary from the true electro-chemical equivalent of the metal, the most important causes of error are as follows :

1. Variation in the current density of plate.

Owing to the necessary presence of free acid in the cell, an error is introduced due to the corrosive action of the acid on the plate, and proportional to the area of plate exposed to such action, so that, with a given current, the electro-chemical equivalent will vary with the area of the plate.

2. Unequal density of liquid in voltameter cell.

The tendency of the liquid to assume unequal density is well known to the electro-plater ; he knows how much his bath is benefitted by occasional stirring up.

3. Variations of temperature.

When temperature variations take place within wide limits, errors are produced which must be allowed for.

Now I maintain that all these elements of error—to guard against which great precautions must be taken even where electro-deposition is used for rough determinations—must of necessity become very much intensified when the voltameter cell is applied under the peculiar conditions holding in the system under consideration.

Consider for a moment the importance likely to be assumed by the corrosion error—an error which, in this case, can only be allowed for by guessing at its amount. The experiments of Mr. Thomas Gray and others would seem to indicate $\frac{1}{7}$th to $\frac{1}{15}$th ampère per square inch of plate surface as the best current density to use where accurate results are wanted. Mr. Lowrie tells us that in his 12-ampère meter he allows four square inches per ampère alternating current when meter is carrying its maximum load. This is quite a small surface of plate when one considers the nature of the liquid resistance in the consumer's circuit ; but when we consider this plate area in relation to the depositing current, what do we find ? The maximum depositing current is only ·2 ampère, with, say, quarter load, or five lamps. We have a depositing current density on the plate of about $\frac{1}{1000}$th ampère per square inch.

Supposing a consumer used very little light for, say two weeks, he then locked up his premises and went away for two weeks ; when he returned, and at the end of the month, the gain plate of his meter was weighed, is it a very improbable further supposition to make that it would be found to have lost weight, and so indicate something due to the consumer by the station people ? Unless, indeed, when he went away he left his supply circuit closed and some of his lamps on, in which case his meter would go on metering the resistance of his circuit (supposing he receives his supply through a converter) 24 hours a day, or as long as any charge remained in the battery, and this, even though a single coulomb had not passed through the primary of the converter.

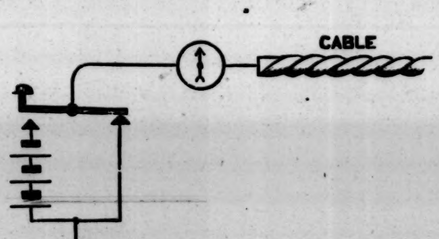
When, in addition, one considers that battery cells require charging and a good deal of looking after, it must be admitted, I think, by those familiar with the practical conditions of efficient meterage, that the very novel and interesting system under discussion does not constitute a very long step towards the solution of the very difficult problem.

R. Shand.

Lynn, Mass., *October 23rd*, 1888.

Galvanometer Discharge Deflections.

In taking discharge tests of a long cable, if the charging current is allowed to pass through the galvanometer thus :—



A small permanent deflection is produced on the mirror by the charging current. How can the effect of this be eliminated from the discharge deflection, *e.g.*, a cable is charged by a battery giving a deflection of two divisions to the left on the scale whilst the cable is being charged, and on the key being released the spot deflects 200 divisions to the right. What is the true discharge deflection ?

A. K.

[As this is an interesting problem it has been answered at length on page 515.—EDS. ELEC. REV.]